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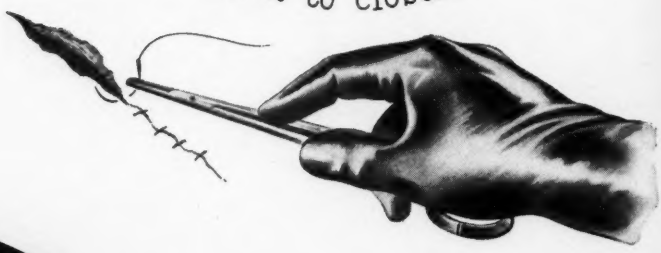

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THE
AMERICAN SURGEON

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FACTORS CONTRIBUTING TO THE PROGRESS OF SURGERY IN THE PAST TWENTY-FIVE YEARS*

J. Duffy Hancock, M.D.

Louisville, Ky.

The silver jubilee of a man's professional life or an organization's span of activity always has appealed to me to be a most dynamic one. The enthusiasm which initiated the work is not yet spent, accomplishments which have been achieved give promise of what more is to come, and tradition is not so securely rooted that one must look backward instead of forward. The foundation has demonstrated its strength, and a sound superstructure can be visualized.

The one discouraging thought comes from the realization that so many of our pioneer builders, tired from their ceaseless service to their fellow-man, have had to lay down their tools and pass to the great beyond. We can hope that the all merciful Great Physician may overlook their frailities and give them rest and happiness.

In an attempt to dramatize or epitomize the factors contributing to the progress of surgery in the past 25 years I would like to use again the reference I used in discussing "Surgical Horizons" a few years ago.

Now, as then, the theme is physiologic surgery—a term borrowed from that colorful and controversial surgeon of the early part of the twentieth century, Dr. Robert T. Morris. He well defined the four eras of surgery as the heroic, the anatomic, the pathologic and the physiologic. The basis for his physiologic era was rather limited—embracing only the proper use of phagocytes, opsonins and other antibodies, rapid surgery to shorten the time of anesthesia, and minimal procedures to avoid damage to normal tissue response.

Morris was a greater prophet than he realized. No fifth era has been added. The refinements and the expanding boundaries of surgery in the past 25 years have been but the crystallization of the physiologic approach to our problems.

We are fortunate in that this Congress was organized at a most propitious time. Surgical diagnosis was rather well established. Most of the procedures

*Presidential address presented during the annual Meeting of the Southeastern Surgical Congress, Feb. 21–24, 1955. Atlanta, Georgia.

we utilize so much today were generally understood and practiced. Technical skill in operating had about reached perfection in the hands of competent surgeons. Wider horizons were to be achieved, but not so much by new procedures as by broader applications of the old. And yet, in spite of this high level of diagnostic ability and operating skill, the over-all accomplishments of 25 years ago pale into dimness when compared with achievements of today. A careful analysis of the factors contributing to this progress shows that, while they were many and varied, most of them had a common denominator—applied physiology. It is this applied physiology which has enabled us to prepare our patients properly for safer surgery. Operations upon the moribund now are largely a thing of the past. It is this same applied physiology that has molded the selection and development of various surgical procedures.

As a result of this trend, a study of the basic sciences, especially physiology, now is required of every properly trained surgeon. If one cares to argue that physiologic advances have been the result rather than the cause of this prescribed study, the answer still is the same—physiology.

In the pathologic era emphasis was placed upon the disease, especially the local lesion. Now we are more inclined to consider the entire body and its functions as affected by the disease.

At the time our Congress was organized, there was great enthusiasm about the possibilities of the sulfonamides represented popularly by prontosil. This drug had gained much recognition by its use in the treatment of an infection in one of President Coolidge's sons even though the outcome was fatal. Numerous types of sulfonamides were introduced and many discarded. However, some, notably gantrisin, still are proving their usefulness. Much of the safer streamlining of intestinal surgery was encouraged by results of sulfonamide therapy.

A step beyond this was the discovery and application of penicillin and other antibiotics. They now are multitudinous in number and constantly increasing because of their demonstrated effectiveness. Their blessings have not been unmixed, but by the physiologic approach with anti-antibiotics some of their distressing side effects have been controlled.

Related to antibiotics and the sulfonamides, but acting in a different manner, are the products considered in the category of chemotherapy. The action of nitrogen mustard represents the beneficial effects that can be obtained by the use of these drugs.

The incidence and course of pylephlebitis, multiple abscesses of the liver, septicemia, and similar conditions, have been greatly curtailed by the use of agents belonging to the groups just discussed.

No longer is blood loss estimated in a haphazard way. Circulating blood volume studies now are fundamental. Because of their effectiveness and availability, transfusions have become commonplace. Even now, though, they are not without danger. Recognition of this fact has led to the development of plasma expanders and excellently prepared intravenous fluids of all kinds. Nearly any type of electrolyte now is readily available. These latter represent a tremendous advance over the old glucose and saline solutions sterilized often on the various wards of the hospital.

Hypodermoclysis, while rarely employed, has been made more acceptable by the use of alidase.

The discovery of the role of potassium in the body economy explains some misunderstood fatalities in the past and accounts for otherwise unexpected recoveries at the present time.

As anesthesiology has made strides, the relationship between the anesthesiologist and the surgeon has become symbiotic. No longer is just the obliteration of pain the sole function of the anesthetist. Properly practiced, the specialty includes life saving procedures, especially oxygenation, makes the bad risk acceptable, and opens the vista of surgical relief to the aged who so long have been denied its benefits. The mortality and morbidity rates associated with the unphysiologic state of anoxemia have decreased as measures for its control have become commonplace. Controlled respiration, the use of intratracheal tubes, tracheostomy, and bronchoscopy all contribute to the proper exchange of gases and prevention of respiratory complications. So-called postoperative pneumonias no longer are considered inevitable. The physiologic importance of simple deep breathing and coughing is well recognized.

The increased use of postoperative recovery rooms in the surgical suite close to both surgeon and anesthesiologist is proving of great value in the control of shock. Waiting until the blood pressure is well stabilized greatly lessens the danger of a long stretcher ride, exposure to cold, and the jarring effects of the elevator.

Early ambulation again has demonstrated the naturalness of the physiologic approach. When employed there are fewer cases of wound dehiscence, pulmonary emboli, and paralytic ileus. With the pressing need that exists to save both beds and money, it is fortunate that early ambulation is such a beneficial procedure.

Venous and plastic grafts now make possible increasing opportunities for the repair of vascular injuries and deformities. An understanding of thrombophlebitis and phlebothrombosis has prevented many embolic deaths. Lumbar sympathectomy is establishing itself as a valuable procedure in certain vascular disorders. In this field of vascular surgery, particularly, members of our Congress have provided outstanding leadership.

The conservation of all possible physiologically functioning tissue has become recognized as a fundamental practice in plastic surgery and accounts for many of its finest results.

With the realization that speed and gentleness are basic factors in atraumatic surgery and the maintenance of physiologic functions, there is an increasing tendency to handle body tissues with dispatch and care.

When our association was organized we were very happy to utilize the increased safety factor of Lugol's solution of iodine in the preoperative preparation of patients who have thyrotoxicosis. Now we have the much more effective antithyroid drugs, such as propyl-thiouracil and radioactive iodine. To all intents and purposes, the day of the preoperative or postoperative thyroid crisis has passed, and with the approach to normal physiologic function of the gland there has been a gratifying drop in operative mortality rate.

Ileus, paralytic or mechanical, always has been a serious surgical problem.

Decompression was long realized as the prime objective in treatment. Levine tube aspiration alone, poorly functioning enterostomies, and ineffectual enemas had given discouraging results. The introduction of the Miller-Abbot and Cantor tubes and Wangensteen suction have been of immeasurable value in preoperative preparation or definitive treatment of these conditions.

The pendulum of regard for vagotomy still swings. The acceptance this procedure will enjoy depends upon the normality of function which it can re-establish. It has contributed to our management of the peptic ulcer problem, and will occupy a permanent place in our surgical therapy—generally in combination with some other surgical procedure. Its physiologic competitor, partial gastrectomy, appears to be more popular at present.

The use of adrenal and other endocrine gland products has become much better established and understood. Adrenalectomy, because it does have some physiologic basis, yet may be properly evaluated and found to be of real service.

One of the brilliant advances of the past 25 years has been in the field of chest surgery. Technical procedures had been available for years but could not be properly applied until the physiology of respiration became well understood. Then the surgical invasion of the chest became inevitable with results that are amazing. Segments, lobes, and lungs are removed to eradicate malignant and nonmalignant disease and restore more normal function. The esophagus now is accessible for radical surgery.

As the feasibility of lung surgery became more apparent, the surgical approach to disorders of the heart aroused an increasing interest. No longer was it limited to the suture of stab and bullet wounds. The correction of inadequate valves restoring the cardiac cripple to a useful place in society is one of surgery's most brilliant achievements.

The same progress was made in pediatric surgery when pediatric physiology finally was appraised as being of more importance than the use of small instruments. Nowhere is re-establishment of physiologic function better illustrated than in restoration of continuity to the gastrointestinal tract in cases of atresia or in restoring to normal disturbed vascular flow.

Tantulum mesh and similar inert products have made possible the repair of many hernias with otherwise unbridgeable defects. They have proved to be effective not because they substitute for tissue but because they serve as a base for the attachment of physiologically functioning tissue.

The advances in industrial surgery largely overlap those considered in other fields with this addition—the safety first program. This effort to protect physiologic function always has been more effective than attempts at restoration after damage has been done.

Procedures for just prolonging life are morally sound and emotionally satisfying. However, mere living is an inadequate existence. There should always be an attempt to restore sufficient function to bring comfort to the patient. Great strides are being made in the rehabilitation of the sick and injured. Nothing can be more gratifying. These tremendous advances in rehabilitation have left an indelible mark upon the record of progress in the past quarter of a century.

Extensive mutilating surgery will become more popularly acceptable in proportion to the comfort it can give rather than to the mortality rate it will show. Most people have an inherent desire not to be a burden upon others. In attempting to restore some acceptable degree of function, we have contributed to the progress of mankind as well as of surgery.

These are but some of the great advances made in the progress of surgery, most of them attributable to the application of the physiologic concept.

There remains one intangible factor to be discussed—the character of the surgeon. Mastery of the basic sciences, brilliance in diagnostic ability, and skill in operative technic mean nothing without intellectual honesty, which is a qualitative and not a quantitative virtue. The very fact that the exposure of an occasional patient to needless operation, an instance of fee splitting, or evidence of overcharging, causes so much publicity proves that such procedures are exceptional rather than routine. Surgeons have kept the faith. There has been no sacrifice in character to detract from the material advances which have been made. On the contrary, a definite part in the training of the young surgeons has been an increasing emphasis upon the art and honesty of the specialty in keeping with its scientific achievements.

It always is tempting to speculate upon the future. We can well wonder what the next 25 years will bring.

Antithyroid drugs and radioisotopes may eliminate the need for thyroidectomy. The cause or cure of cancer may be discovered. Tuberculosis may largely become a surgical disease. On the other hand, the control of cholesterol physiology may transfer the treatment of gallbladder disease to the internist.

Advances in vascular surgery will save many lives as well as many limbs. Newer methods of stimulating body resistance can be expected and more secrets of endocrinology will be unlocked.

Regardless of the limitations that may be imposed upon present day surgical procedures, the specialty always will remain a fascinating one. Physiology can be depended upon to open new frontiers replacing fields that have been conquered.

The membership of our Congress, embracing research worker, specialist, and practical general surgeon can be depended upon to make its contributions in meeting these challenges.

Our philosophy must never deviate from the principle that no surgery is complete when it is divorced from consideration of the restoration of essential function. That concept will ever justify the essentiality of surgery in all its branches. The essentiality of the surgeon himself will continue to depend upon his integrity.

EARLY RECOGNITION AND SURGICAL TREATMENT OF CARCINOMA OF THE LIP

BROMLEY S. FREEMAN, M.D.

Houston, Texas

Cancer of the lip in its prominent and exposed positions can be recognized and treated early and result in a complete cure. This ideal situation can be modified by ignorance, fear, indifference and procrastination by the patient and by uncertainty, inexperience and prejudice on the part of the physician and may result in delayed, incomplete or improper treatment. Nonetheless, cure rates of previously untreated carcinomas of the lip vary up to 90 per cent in the hands of special groups although nodal involvement immediately decreases the rate by 50 per cent.

The textbook type of lesion with bilateral cervical adenopathy shown in figure 1a was seen several months after inadequate or improper radiation therapy. This obvious and resistant malignancy, invading the entire lower lip and one of the angles, was resected (fig. 1b) and bilateral neck dissections were done. When it was apparent that no systemic spread of metastases had occurred, a series of plastic maneuvers were carried out with the final result as shown (fig. 1c). The patient is now a six year cure with good function and fair cosmetic result. However, no statistical table of cure rates will show the months of post-irradiation pain, the postoperative drool, the prolonged economic loss, and the severe social and psychologic stress incident to this cure. Beside our cure rate tables there should be a morbidity and disability schedule.

Repeatedly has the dictum been emphasized that the earlier the diagnosis the less the economic disability and the smaller the functional and cosmetic deformity. The curability of a specific lip lesion depends upon its duration, size and grade of malignancy. Metastatic spread, which changes a relatively innocuous disease to an incurable one in almost 50 per cent of the patients, is directly dependent upon these factors. Obviously, the sooner the diagnosis is established and the malignancy removed, the better the prognosis.

How then can we improve our diagnostic ability and minimize the morbidity rate? Why not seek to treat the lesion in the premalignant or precancerous stage? Concepts of precancerous tissue are as wide or as narrow as desired. In general, precanceroses have been found to have a certain specific reaction pattern;—the tendency to develop carcinoma in statistically significant numbers. In the production of a lip malignancy there seem to be two factors at work; one intrinsic, the other extrinsic. The intrinsic factor is composed of those changes in structure and functioning of the lip covering whereby it loses its protective capacity against injuries. The extrinsic factors are those experimentally proved such as chemical irritation, carcinogens, multiple traumas and the ultraviolet

*From the Department of Surgery, Baylor University College of Medicine, Houston, Texas.

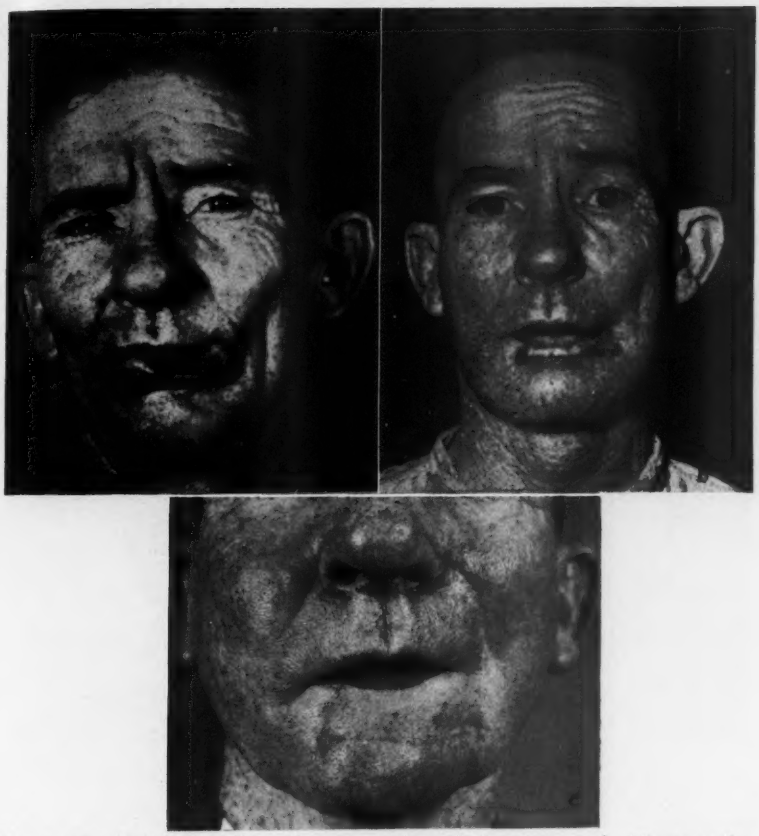

FIG. 1a. Textbook picture lip malignancy with cervical metastases. b. After resection of primary lesion and partial closure. c. After bilateral neck dissection and cheiloplasty.

light which provoke the reaction pattern. If either factor is sufficiently strong the other is not necessary.

Bloodgood has shown, early in this century, that in 200 cases of cancer of the lip not one started in normal skin or mucous membrane. Precancerous tissue is at best worn out and shows evidence that the organism is trying to increase the defenses against the daily wear and tear. Emollients, estrogens, vitamins used by all of us to correct these deficiencies usually seem to allow for continued procrastination when a patient with leukoplakia, keratosis, prolonged fever blisters, smokers patches, and chronic cracked lip appear on the scene. It is our contention that the majority of cancers of the mucous membrane of the lip really are scar cancers on a tissue base with a disturbed maturation pattern and frequently are multicentric in origin. These centers of activity may be so small as to be unobserved but a very close search often will reveal them. We believe that attempts to remove the precancerosis by radiation, cautery or pastes cause

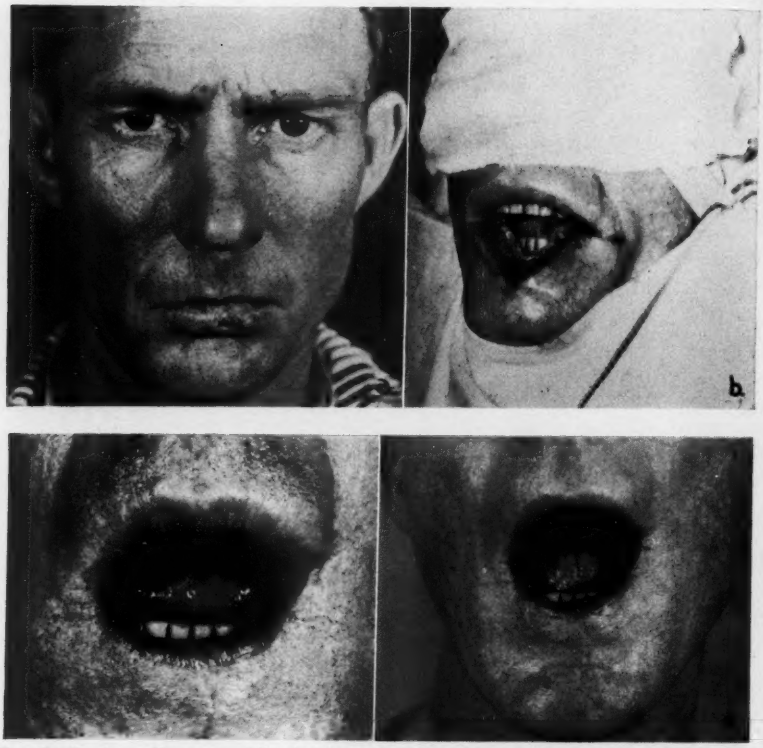

FIG. 2a. Early malignancy of lip. b. V-excision, lip shave and Bernard plastic operation. c. Immediately postoperative. d. Three months postoperative; note resolution of angle redundancy.

further scarring which remains as a potential and often increased source of danger. Excision of the entire exposed, worn out, irritated tissue and replacement with mucous membrane from the mouth leaves new tissue, cosmetically normal, which rapidly accomodates itself to environment and which may last for many more decades without evidence of wear and tear.

The second patient (fig. 2) with a fairly early malignancy of the lip is interesting because of the character of the surrounding tissue. V-excision and a removal of all the exposed vermilion surface (plus an immediate Bernard triangle chieloplasty) allowed us to study the entire lip covering. Two separate sites of *carcinoma in situ* were found. When first seen the patient was given a *chapstick* and observed for six months. When the *fever blister* grew he was referred to us.

During 1947 and 1948 at the Tumor Clinic of McCloskey Veterans Administration Hospital we were privileged to examine 80 *precanceroses* of the lip—lesions of the lip not believed to be malignant by referring clinicians, who, cognizant of our interest in such matters, kindly offered to send them our way. During

TABLE 1

Diagnostic Errors

Malignant Lesions Called Benign

By clinician	20–50%
By tumor board	11–27.5%

History as a Diagnostic Aid

	Duration	*Age*
Benign	1 mo.–20 yr.	25–63
Malignant	3 mo.–20 yr.	27–63

TABLE 2

The 40 Precanceroses

Benign		*Malignant*	
Leukoplakia	7	Carcinoma in situ	7
Hyperkeratosis	8	Squamous gr. I	4
Bowenoid Hyperplasia	3	Squamous gr. II	7
Chronic Chielitis	2	Squamous gr. III	1
		Base-squamous	1

this specific period we were able to study 40 microscopically and these were reviewed to correlate the diagnosis of the referring practitioner and of the consensus of the tumor board opinion with that of the pathologist. Age of the patient, duration of the lesion, exposure, and occupation were studied and a few of these factors can be reviewed here. Table 1 shows the diagnostic errors. If a group of *boarded* specialists consisting of a dermatologist, internist, radiologist, pathologist and plastic surgeon, can have an error of 27.5 per cent and an alert group of general practitioners a margin of 50 per cent error, it would seem that only microscopic study of a total biopsy specimen of a *precancerous* lesion of the lip would determine its early malignancy. As shown, there was little difference in duration of benign and malignant lesions, and similarly little difference in the age range. Table 2 shows the histologic break-down in the 40 so-called precanceroses. Only histologically could an accurate differentiation between early malignant and precancerous lesions be made.

In the Southwest where keratosis of the skin and lip is an occupational disease of the outdoor worker or sportsman, and where most of us are receiving great quantities of sunlight all year, this differentiation can be a frequent problem. All lesions with thick patches of leukoplakia, keratoses, chronic scaling, persistent inflammatory ulcers or recurring fissures require treatment. We have advocated, and the photographs will depict (fig. 3), a simple total excision of the exposed vermilion surface of the lip, advancement of the mucosa to the edge of the skin and the microscopic study of the total specimen. This leaves a barely perceptible scar and minimizes mortality, morbidity and cosmetic deformity.

I have selected a few illustrative cases. The next two photographs represent the relatively younger age group. The first, a 31 year old farmer, had a lip lesion present for four years which microscopically proved to be benign (fig. 4a). The

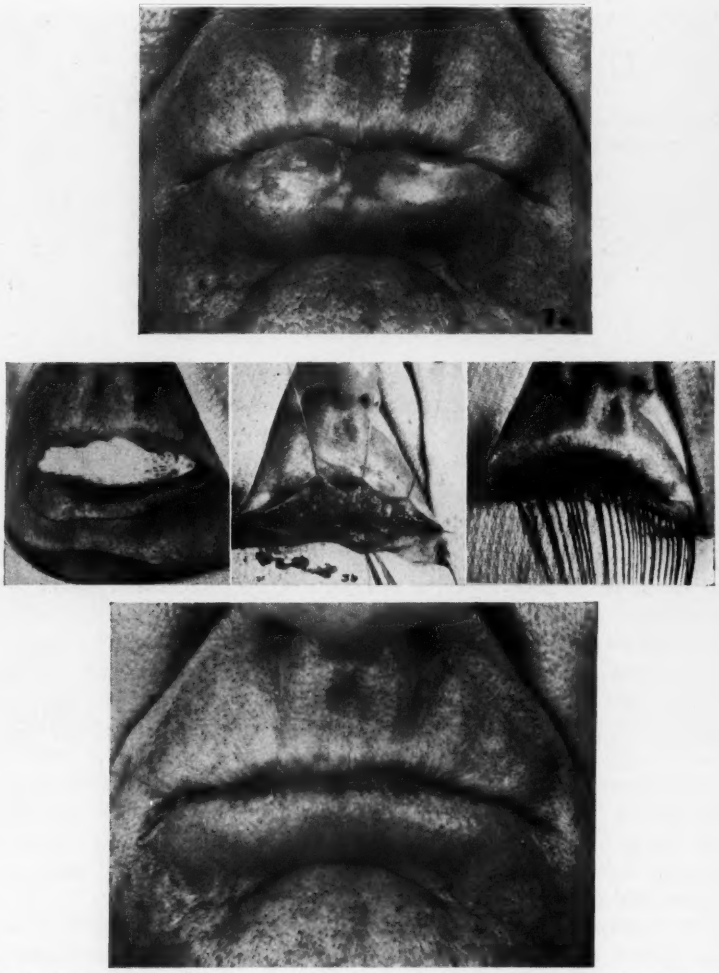

FIG. 3a. Precancerous lip lesion. b. Technic of *lip shave*. c. Post operative, two weeks.

second, a 27 year old mortician student was in the hospital for hepatitis that he acquired in the South Pacific, had a lesion of six months' duration which, on microscopic study, was carcinoma, squamous cell, grade II (fig. 4b).

The next 3 patients are of the relatively older group in their sixth decade, and had their lesions two months, one year and one year, respectively. The first lesion, duration two months, was squamous cell cancer; the last two, leukoplakia (fig. 5).

Figure six shows an uncommon lesion of both upper and lower lips in a 61 year old outdoor laborer who had been treated with surface radium a year prior

FIG. 4a. Leukoplakia, four years duration. b. Carcinoma, squamous cell grade II; duration six months.

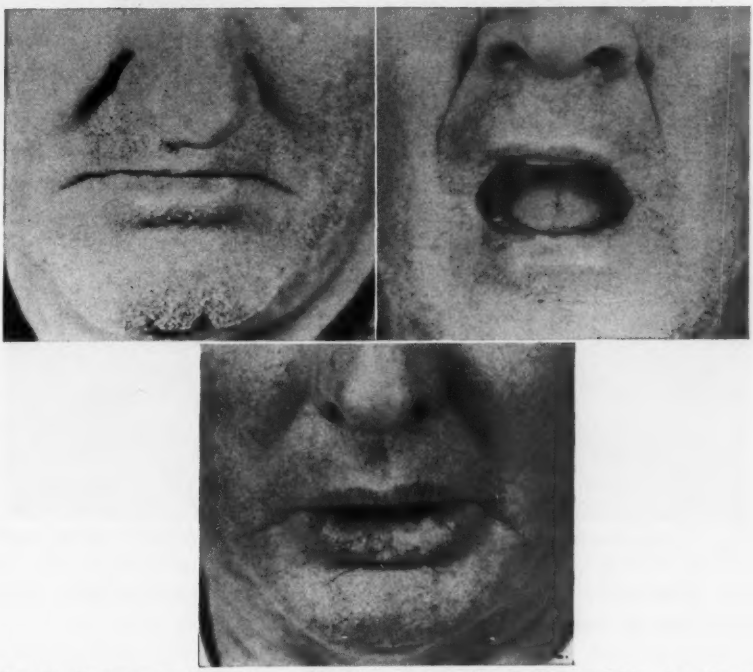

FIG. 5a. Squamous cell carcinoma duration two months. b. Leukoplakia, duration one year. c. Leukoplakia, duration one year.

to our seeing him at the tumor board. Microscopically, superficial squamous carcinoma was found when specimens from both lips were examined. An oil driller, 52 years of age, in the hospital for cardiac failure, had been greasing his lips with lanolin for several years (fig. 7a). As you have probably come to

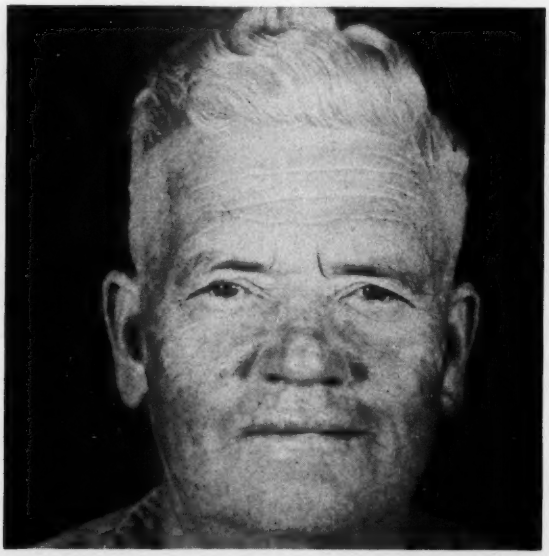

FIG. 6a. Superficial squamous cell carcinoma, upper and lower lips.

Fig. 7a. Squamous carcinoma grade I, duration two years. b. After excision of exposed vermilion border and closure.

expect, histologic study of the total specimen revealed carcinoma grade I. The last photograph shows his condition on discharge (fig. 7b).

CONCLUSIONS

If we could regard every superficial induration and every persistent fissure or ulcer of the lip as cancer, and if we could look upon all so-called chronic irritations of the lip with grave suspicion, we could truly attack the cancers in their incipiency with resultant lowered morbidity and less cosmetic, functional and economic disability. I have tried to show that early recognition depends upon early surgery.

THERMAL BURNS IN MAN

VI. BODY FLUID COMPARTMENTS DURING EARLY THERAPY*

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The retention of a portion of the relatively large volume of fluid currently administered in treating patients with extensive burns almost invariably results in a weight gain of several kilograms during the first 72 hours.[5] The purpose of the present study was to attempt to determine the compartmental distribution of the retained fluid. That a significant quantity of this fluid may remain in the extracellular space often is manifested by a generalized edema of clinical magnitude. Moreover, Cope and Moore[2] did serial thiocyanate space and plasma volume studies in burn patients and found that the apparent volume distribution of the thiocyanate ion increased markedly during the first few days of therapy. The conclusions reached by these workers and by Fox [3,4] are supported by our findings.

PROCEDURE AND METHODS

The patients studied were individuals admitted to the wards of the John Gaston Hospital with thermal burns that exceeded 20 per cent (range, 20–85) of the body surface area. Immediately after admission measurements of plasma and blood volume (T-1824 and venous hematocrit) were made. At the same time sodium thiocyanate and deuterium oxide (heavy water) were injected for the measurement of the *extracellular space* and the total body water, respectively. The blood sample for the determination of plasma and blood volume was drawn at 10 minutes, that for thiocyanate distribution at 45 minutes, and that for the D_2O dilution space at 2-hour intervals. The concentration of heavy water in the plasma samples was determined by the falling drop method. Two of the 6 patients whose results are shown (J. A. and A. B.) were in some degree of shock during the initial blood volume measurement. Promptly after the blood volume was drawn colloid material was rapidly infused intravenously. Thus, shock existed in these 2 patients (J. A. and A. B.) during only a fraction of the time allowed for thiocyanate equilibration and it existed an even smaller fraction of the time allowed for D_2O equilibration. No correction was made for urinary loss or for

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the penetration of red cells by a portion of the thiocyanate. This doubtless rendered the measured extracellular space apparently larger than actually was the case. Nevertheless, we were chiefly interested in the variations which might occur in this volume, and the technic employed was uniform throughout.

RESULTS

Thiocyanate Space Changes. The data are presented in table I and in figures 1 and 2. The *thiocyanate space* increased sharply in the 6 patients shown here and in the 1 additional patient so studied. The increases in this space in patients L. W. and J. H. (fig. 1) were 7 and 3 liters, respectively; their maximum increases in body weight were 6 and 7 kilograms. The increase in the thiocyanate space in patient A. B. was 12 liters at the time of the maximum weight increase of 4 kilograms. In figure 2, patient M. S. exhibited an increase of approximately 5 liters in the thiocyanate space and a weight increase of2 kilograms. The thiocyanate space increase in J. A., who had an overwhelming burn of the charring type, was 12 liters and the weight increase 7 kilograms. He was essentially anuric until death, and large quantities of fluid (almost 13 liters) were necessary merely to sustain life. At autopsy the pericardial sac contained 250 cc. of fluid and each hemithorax contained approximately 1 liter. Patient A. W. exhibited the tremendous increase in thiocyanate space of almost 20 liters, while gaining 12 kilograms. Since it would seem questionable that the extracellular space actually increased by this amount, it is possible that the apparent increase in the thiocyanate space could have resulted in part from a penetration of the cells by the thiocyanate ion. One additional patient, whose results are not presented in figures 1 and 2, exhibited a thiocyanate space increase of 8 liters while gaining only 5 kilograms; the curves for both thiocyanate space and body weight increase in this subject were similar in contour, and both returned to the admission base line on about the eighth postburn day.

Plasma and Blood Volume Changes. In 4 of the 5 patients shown in figures 1 and 2 in whom multiple measurements were made, the effect of early colloid therapy was to increase both the total blood and plasma volumes.
In 1 patient (J. H.), however, the blood volume tended to diminish as the plasma volume increased; here the declining total blood volume may have reflected a

TABLE I

Patient	Sex	Age	Admission Weight (Kg.)	Per Cent Burn*
M. S.	F	77	39.5	20/17
J. A.	M	35	66.2	85/70
A. W.	F	53	72.7	53/40?
A. B.	F	82	69.8	35/30
L. W.	M	32	77.7	50/15
J. H.	M	41	77.7	35/17

* The first figure represents the total per cent of body surface area burned, the second the approximate extent of third degree injury.

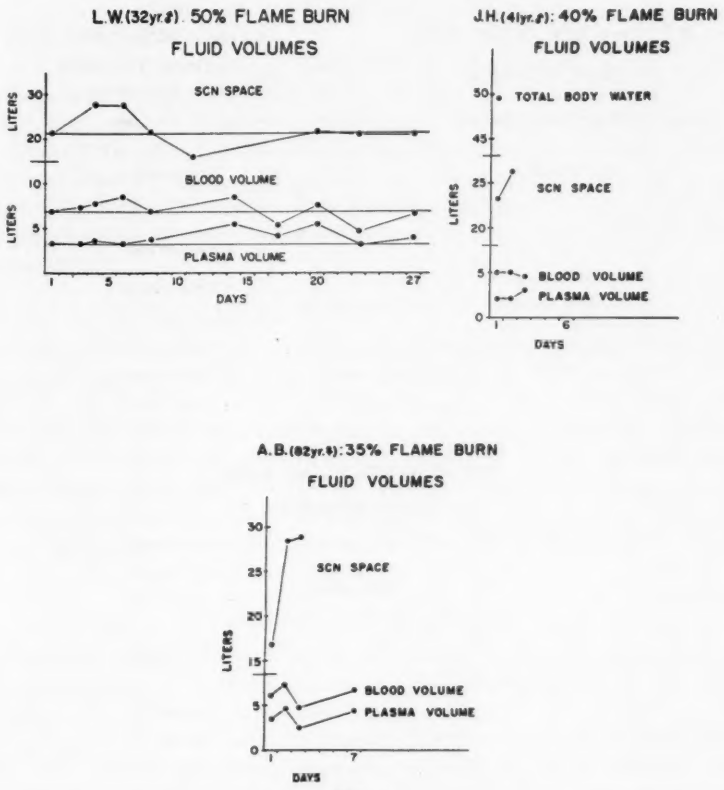

FIG. 1

more rapid depletion of red cell mass than of plasma volume. In general, the changes in plasma and blood volumes were less marked than were the changes in the thiocyanate space.

Total Body Water Measurements. The single determination of total body water, on admission, was made to afford a base line against which variations in the body weight and the thiocyanate space might be considered.

DISCUSSION

Fate of The Infused Fluids

Extracellular and Intracellular Compartments. In 5 of the 6 patients whose data are presented in figures 1 and 2 the observed increase in the thiocyanate space exceeded the gain in body weight derived from the administered fluids. On the

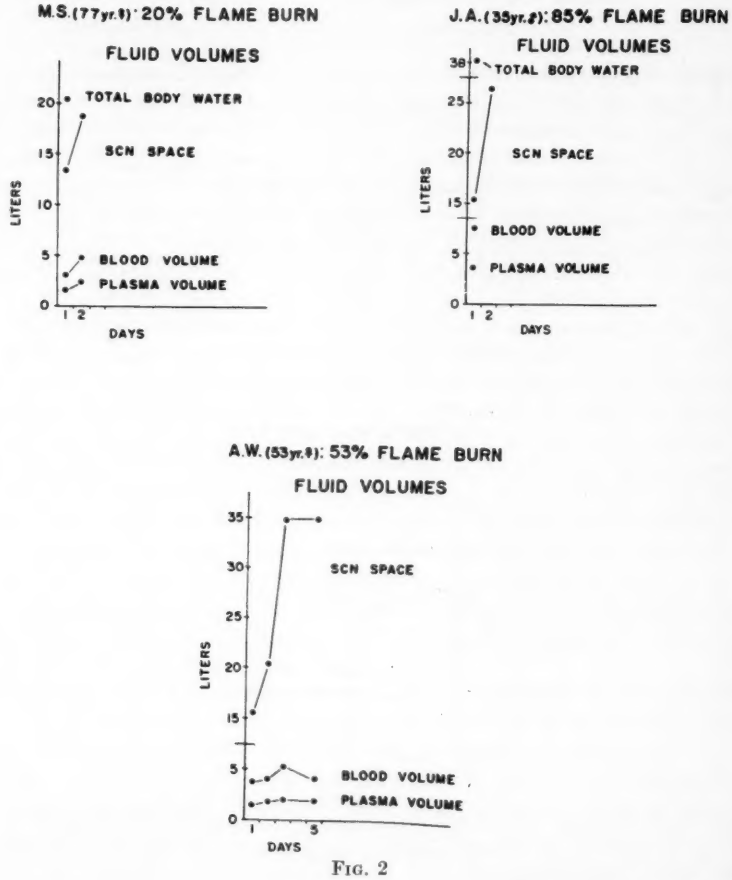

FIG. 2

basis of the thiocyanate measurements, the fact that the extracellular fluid increase exceeded the weight increase in 5 of the 6 patients would appear to indicate not only that the infused fluids increased the extracellular space, but also that water can be drawn from other areas of the body (and perhaps from both extracellular and intracellular sources). It is also apparent from the considerable edema which occurs adjacent to the burned areas even in patients whose fluid therapy has been delayed. Moreover, Blalock[1] showed that if one side of an animal were burned and the animal killed hours later, the carcass of the burned side weighed significantly more than did the carcass of the unburned side.

The results of the long continued study of patient L. W. (and of a subsequent subject whose results are not shown) further support the conclusion that the extracellular space is increased during early fluid therapy in burns. The curve reflecting body weight changes bore a positive relationship to the curve for thiocyanate space.

Red Cell Loss. The significant destruction or other loss of red cells which occurred is apparent from the fact that in those patients who were followed long enough there was often an early tendency for the red cell mass to decline, as exhibited by the fall in total blood volume in the absence of a concurrent decline in plasma volume (L. W., J. H., and A. W.). Even in these patients, however, frequent whole blood transfusions were used to prevent a fall in the venous hematocrit to a level significantly below 40 volumes per cent. Large quantities of blood were necessary.

Collateral Evidence of Variations in Cellular Hydration

It has been shown that the intravenous infusion of hypertonic saline solution may dehydrate the cells[6] and also may cause alterations in the electroencephalogram.[7] It is possible that certain of the mental changes that are at times observed in severely burned patients may be due to alterations in the state of brain cell hydration. Moreover, we have treated 1 extensively burned patient who, in coma without hypotension on approximately the ninth postburn day, was made rational by the infusion of 5 per cent glucose in water. This solution enters cells readily and has been shown to increase the cerebrospinal fluid pressure, presumably due to increased brain hydration.

SUMMARY AND CONCLUSIONS

The plasma volume, blood volume, thiocyanate space and total body water have been studied in 7 patients whose burns exceeded 20 per cent of body surface area. The results in 6 are presented graphically.

The thiocyanate space increased (range, 4 to 20 liters) in all patients studied, as did body weight. The curves representing the increases in thiocyanate space were similar to those (not shown) representing increases in body weight in the respective patients. The increase in thiocyanate space generally was proportional to the per cent of body surface area burned, as was the increase in body weight; the volume of fluid infused was based upon the area of burn. When the individual was followed long enough, the curves depicting thiocyanate space and body weight changes tended to return to the admission base line at approximately the same time. However, the increase in thiocyanate space (liters) usually exceeded by a considerable margin the increase in body weight (kilograms).

It is concluded that the extracellular space is significantly increased during early fluid therapy in burn patients. It is further concluded that either the thiocyanate ion enters the intracellular fluid compartment more readily following thermal burns, or that a considerable volume of water moves from the intracellular to the extracellular compartment. The magnitude of the apparent volume of water leaving the intracellular compartment suggests that, even should the

thiocyanate ion more readily enter the cells following burns, a significant amount of water does leave the cells. This could be due in part to cellular destruction.

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CARCINOMAS OF THE COLON, RECTUM AND ANUS

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During the 24 year period from 1925 throught 1948 the microscopic diagnosis of carcinoma of the large bowel was made on 251 patients at the Vanderbilt University Hospital. We were able to follow all but 8 of these patients (96.8 per cent). In every instance the microscopic diagnosis was made and treatment instituted more than 5 years prior to initiation of this study. The data compiled form the basis for this report.

RELATIVE FREQUENCY

At the Vanderbilt University Hospital during the period 1925 to 1948 carcinoma of the large bowel was surpassed in frequency only by carcinoma of the skin and oral membranes in males and by carcinoma of the cervix uteri, skin and breast in females.[1]

Fifty-two and two-tenths per cent of the patients were in the sixth and seventh decades of life and 73.7 per cent were in the fifth, sixth and seventh decades. The youngest patient was 20 and the eldest 84 years of age (fig. 1). There were 129 males and 123 females. There were 224 white patients and 28 Negroes in the survey, the ratio of admissions of white to Negro patients being 9 to 1.

DURATION OF SYMPTOMS

An attempt was made to determine whether or not patients sought and received treatment earlier in the 8 later years (1941 to 1948) than in the previous 16 years (1925 to 1940). The early group consists of the 99 patients seen from 1925 through 1940, whereas there were 152 patients (1 had 2 such tumors) in the late group seen from 1941 through 1948.

The average duration of symptoms from onset to definitive treatment was 11.4 months for all patients, 12.1 months in the early group and 10.9 in the late group (fig. 2). In order to determine whether the patients or physicians were responsible for this slight improvement, the total duration of symptoms was divided into two subperiods. We determined, first, the average duration of symptoms from onset to the first visit to a physician, and second, the average duration of symptoms from the first professional visit to definitive treatment. The patients sought medical treatment an average of 5.8 months after the onset of symptoms in the early group and 5.3 months in the late group (fig. 3). The time elapsing from the first professional visit to definitive treatment was 6.8 months in the early group and 5.9 months in the late group (fig. 4). Thus, the delay by the patient was less than that by the first physician consulted. However,

From the Department of Surgery, Vanderbilt School of Medicine, Nashville, Tenn.
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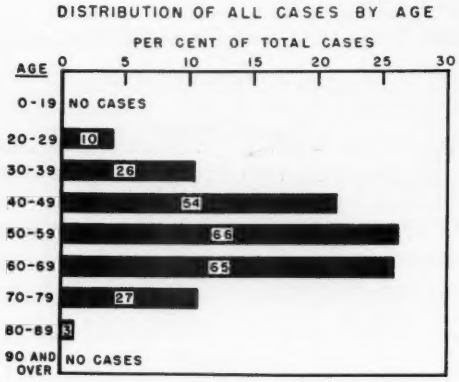

FIG. 1

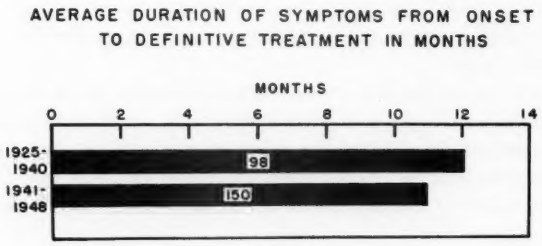

FIG. 2

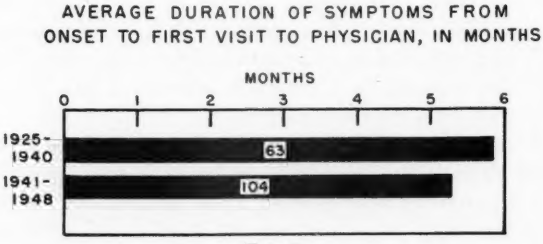

FIG. 3

in some instances, further diagnostic studies and treatment were delayed by remonstrative patients. On the other hand, 10 per cent of the patients were treated for hemorrhoids and 9 patients had major abdominal surgery upon organs other than the colon which contained the malignancy after the onset of their large bowel symptoms. These operations were: appendectomy in 4 patients, hysterectomy in 2 patients and oophorectomy, prostatectomy and drainage of an intra-abdominal abscess in the other 3 patients. The average total duration of symptoms was 8.4 months in those patients who survived 5 years as compared to the total duration of 11.4 months in all patients (fig. 5).

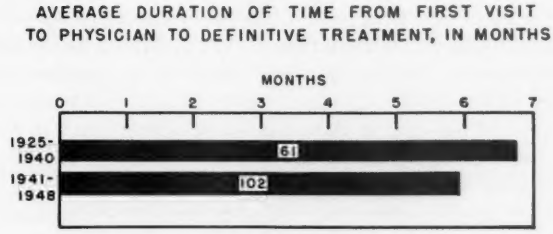

FIG. 4

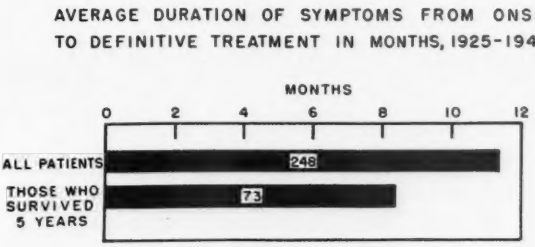

FIG. 5

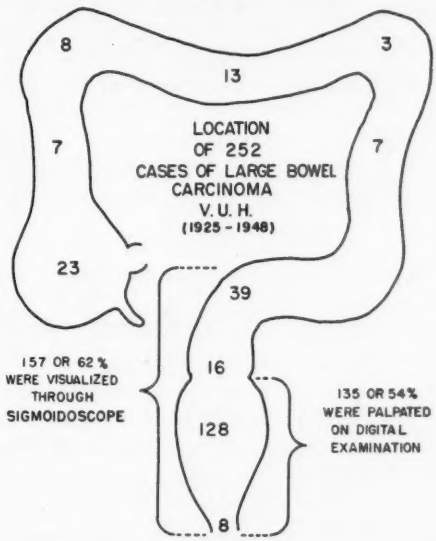

FIG. 6

ANATOMIC LOCATION

The location of each tumor was designated according to the surgeons' operative notes with the exception of those patients in whom no operation except a biopsy section was done. There were more carcinomas in the rectum (128) than in all

other sites in the large bowel (fig. 6). Of the 252 neoplasms, a rectal tumor actually was palpated by digital examination in 135 patients or 54 per cent of all the large bowel carcinomas. The importance of digital rectal examination cannot be overemphasized. An additional 22 tumors were visualized sigmoidoscopically so that 157 tumors—62 per cent of the total—were within reach of the sigmoidoscope. Twenty-two of the cecal carcinomas and 40 of the ascending colon to rectosigmoid tumors were palpable on abdominal examination. Thus, 219 or 87 per cent of all the tumors were either palpable rectally or abdominally or visualized proctoscopically.

CLINICAL MANIFESTATIONS

Because the symptoms of carcinoma of the large bowel vary according to the location of the tumor, the large bowel was divided tnto three main divisions: the cecum, the area from the ascending colon through the rectosigmoid, and the rectum.

The five major symptoms of carcinoma of the cecum in order of descending frequency were pain, weight loss, weakness, obstructive complaints and mass. In the ascending colon to rectosigmoid division the most frequent symptoms were pain, change in bowel habits, weight loss, obstructive complaints and blood in the stools. The cardinal symptom of carcinoma of the rectum was bleeding,

TABLE I

Five Major Symptoms of Carcinoma of the Large Bowel

Symptom	Cecum	Ascending Colon To Recto-Sigmoid	Rectum
Change in bowel habits		89.2%	90.5%
Melena		61.3%	93.6%
Pain	96.8%	91.6%	59.3%
Weight loss	83.6%	75.8%	73.3%
Weakness	70.4%		
Obstruction	52.8%	72%	
Tenesmus			54.6%
Mass	66%		

TABLE II

First and Presenting Symptoms of Carcinoma of the Large Bowel

Symptom	Cecum		Ascending Colon To Recto-Sigmoid		Rectum	
	First	Presenting	First	Presenting	First	Presenting
Change in bowel habits			42%	19.4%	51.5%	33.6%
Melena				19.4%	53%	59%
Pain	66%	70.4%	44%	62%		
Mass	22%	48.4%				

Percentages are based on total number of cases. Some of the patients had more than one first and presenting symptom.

TABLE III

Chief Physical Findings in Carcinoma of Large Bowel

Finding	Cecum	Ascending Colon to Recto-Sigmoid	Rectum
Mass R.L.Q.	96.8%		
Tenderness over mass	79.2%		
Abdominal mass		41.9%	
Abdominal tenderness		41.9%	26%
Signs of obstruction		46.2%	
Dehydration		16.1%	
Rectal tumor			95.3%

followed by change in bowel habits, weight loss, pain and tenesmus (table I). The most frequent *first* symptoms also were the most frequent *presenting* symptoms. An impression was gained that patients ordinarily are not overly concerned with minor alterations in their bodily efficiency until pain and hemorrhage occur (table II).

The physical findings were rather specific in the cases of carcinoma of the cecum and rectum but somewhat less well defined in those tumors located in the ascending colon to rectosigmoid division. A mass in the right lower abdominal quadrant was palpated upon examination in all but 1 of the patients who had carcinoma of the cecum and there was tenderness over the mass in 79.2 per cent of the cases. There were signs of varying degrees of large bowel obstruction in 46.2 carcinomas of the ascending colon to rectosigmoid. In 41.9 per cent of the patients in this division an abdominal mass with tenderness upon palpation was found. The chief physical finding of carcinoma of the rectum was a palpable rectal tumor, present in 95.3 per cent of cases (table III).

THE BARIUM ENEMA

Carcinoma of the cecum was diagnosed correctly by 14 of the 18 barium enemas studied. A deformity interpreted as *inflammatory*, *tuberculosis*, or *small bowel obstruction* was demonstrated in the remaining four examinations. A barium enema was done in 75 of the patients who had carcinoma in the ascending colon to rectosigmoid division and in 69 of them the roentgenologic diagnosis of carcinoma was made. The tumor was described as *completely or almost completely* obstructing the lumen of the bowel in 65 of the patients. The large bowel was considered normal on two occasions, a polyp was identified in a single patient, and three examinations were interpreted as demonstrating deformities compatible with diverticulitis. The fact that carcinoma of the rectum was demonstrated in 17 of 25 barium examinations indicates that these tumors were rather far advanced.

TREATMENT

Emergency operations on the day of hospital admission, or as soon as the patient could be made reasonably safe for the procedure, were done upon 25

TABLE IV

Emergency Operations for Obstruction

Site	No.	%	Deaths
All sites	25	10	3
Cecum	4	17	0
Ascending colon	1	14	0
Hepatic flexure	1	12	0
Transverse colon	1	7	0
Splenic flexure	2	66	0
Descending colon	3	42	1
Sigmoid colon	10	25	1
Recto-sigmoid	2	12	0
Rectum	1	0.8	1

TABLE V

Operations for Complete Large Bowel Obstruction

Location	Procedure	No.
Cecum	Ileo-transverse colostomy	2
	Right colectomy	1
	Drainage of abscess	1
Ascending colon to rectosigmoid	Cecostomy	7
	Mickulicz's resection	7
	Transverse colostomy	2
	Right colectomy	1
	Left subtotal colectomy (with cecostomy)	1
	Sigmoid colostomy	1
	Cause for obstruction not found	1*
Rectum	Sigmoid colostomy	1*

* Post-operative death.

patients who exhibited evidence of complete large bowel obstruction (tables IV and V).

The treatment of carcinoma of the large bowel is excision of the tumor in continuity with its predictable avenues of primary lumphatic spread. Because of the long period of time that this study encompasses and the fact that 17 surgeons performed the operations, there was a lack of standardization of operability, resectability and type of operation.

Within the past several years there has developed a refinement in the terminology employed regarding palliative resection and curative resection. Today we speak of palliative resections and curative resections, whereas, in the years under discussion, palliative surgery referred only to those patients in whom an attempt at restoration of function was made without removing the cancer. Resectability in this report simply signifies that the bowel containing the primary tumor was excised.

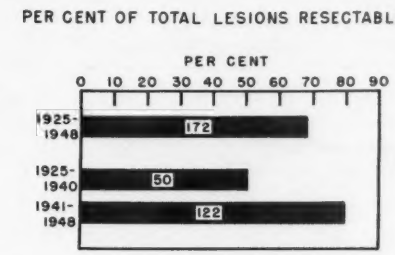

FIG. 7

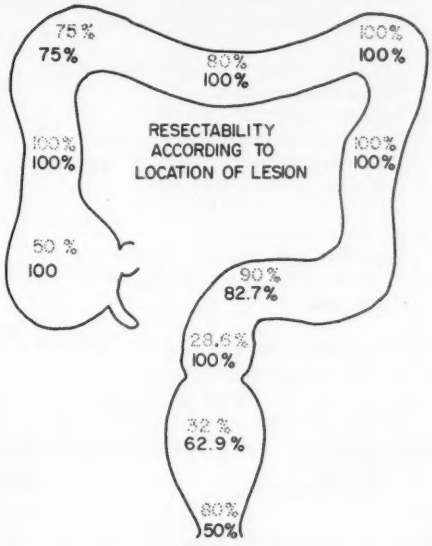

FIG. 8

TABLE VI

Comparison of Resectability

	Early (1925–1940)	Late (1941–1948)
Biopsy	12.1%	7.1%
Palliative Surgery	37.7%	13.0%
Resected	50.1%	80.0%

In this series biopsy, alone, was done in 23 patients (9.1 per cent), palliative surgery in 57 (22.6 per cent) and resection in 172 (68.2 per cent). In the early group (1925–1940), 12.1 per cent of the patients were considered inoperable, whereas, in the late group (1941–1948) only 7.1 per cent of the patients were considered inoperable. Inoperable cases are those in which it was the surgeon's opinion that the patient would not benefit from even palliative surgery because

TABLE VII

Operations Performed

Location	Procedure	Early (1925–1940)	Late (1941–1948)
Cecum	Right colectomy	10	18
Ascending colon	Mickulicz's resection	2	0
Hepatic flexure			
Transverse colon	Resection with primary anastomosis	1	13
Splenic flexure	Mickulicz's resection	6	1
Descending colon	Obstructive resection	0	1
	Proximal cecostomy with resection	0	8
Sigmoid	Resection with primary anastomosis	1	16
	Mickulicz's resection	7	7
	Abdomino-perineal	1	3
	Proximal cecostomy with resection	0	9
	Proximal transverse colostomy with resection	0	2
Rectosigmoid	Abdomino-perineal	1	4
	Resection with primary anastomosis	1	4
	Resection with permanent sigmoid colostomy	0	1
Rectum	1 stage abdomino-perineal	15	40
	2 stage abdomino-perineal	1	4
	Resection with primary anastomosis	0	2
	Proctectomy with or without colostomy	0	7
Anus	Proctectomy	3	1
	Abdomino-perineal	1	0

of the advanced stage of the disease. It is apparent that this group may have been subjected to a considerable divergence of opinion. Palliative surgery was done in 37.7 per cent in the early group, but in only 13 per cent of the late group; 50.1 per cent of the patients in the early group and 80 per cent in the late group were subjected to colon resection (fig. 7 and table VI).

The types of operations for carcinoma of the different sites are shown in table VII. Figure 8 demonstrates the resectability of the various lesions according to location and period. Surgery was no more radical in the late period than in the early one. In 1 patient in the late group the tumor could not be removed and a sigmoid colostomy was done. This patient lived 6½ years and died of uremia due to ureteral obstruction produced by the tumor. At autopsy, no evidence of tumor could be found in lymph nodes or liver.

OPERATIVE MORTALITY

There was considerable lowering of the operative mortality rate in the later years. There were 32 deaths directly related to surgery or in the first 30 post-

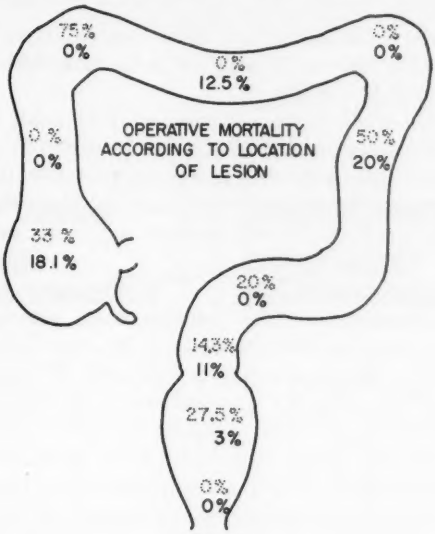

FIG. 9

OPERATIVE MORTALITY

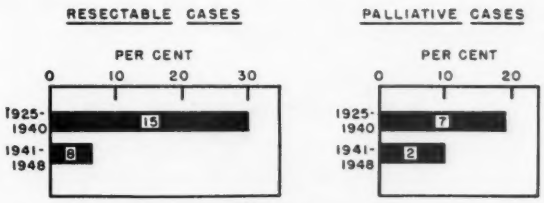

FIG. 10

OPERATIVE MORTALITY OF ALL CASES
(RESECTABLE AND NON RESECTABLE)

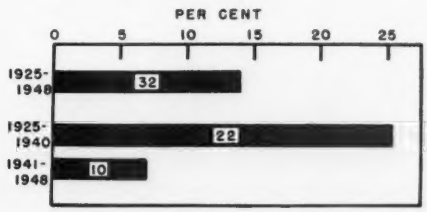

FIG. 11

operative days in the entire series for an operative mortality rate of 14 per cent. In the early group the operative mortality rate was 25.3 per cent, whereas, in the late group it had been reduced to 7 per cent (fig. 9).

The operative mortality rate of the resectable tumors was 30 per cent in the

early and 6.5 per cent in the late period. When only palliative surgery was done, the operative mortality rate was 19 per cent in the early period and 10 per cent in the late period (figs. 10 and 11).

Of the 22 operative deaths in the early period 15 were due to peritonitis (11), shock (2), or intestinal obstruction (2). Of the 10 operative deaths in the late period 5 were due to peritonitis (3), shock (1), or intestinal obstruction (1). There were 7 patients in the early group in whom a leak at the anastomosis was found at postmortem, but only 2 such patients in the late group.

PATHOLOGIC FINDINGS

The pathologic diagnosis in every instance was adenocarcinoma with the exception of the 8 squamous cell carcinomas of the anus. In some of the adenocarcinomas the terms *colloid* and *papillary* were used. No attempt was made to grade the lesions. There were 172 specimens excised in the entire series, in 68 (39.5 per cent) of which carcinoma could be identified microscopically in the lymph nodes. In the early group 44 per cent of the specimens contained tumor bearing lymph nodes while in the late group 37 per cent of the specimens showed metastatic tumor in the lymph nodes (fig. 12). Table VIII shows the pathologic findings in regard to encirclement of the bowel by the tumor. The data regarding polypoid adenomas in these patients are as follows: 1 patient with carcinoma of the cecum had polyposis; 2 patients with sigmoid lesions had carcinoma in single polyps; in patients with rectal lesions, 6 had polyposis in addition to the carcinoma and 5 had carcinomatous polyps.

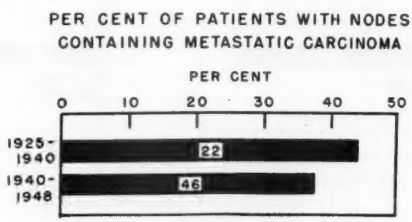

FIG. 12

TABLE VIII

Gross Description of Pathological Specimens Resected

Location	No. Resected	Annular	Incomplete Encirclement	Complete Encirclement
Cecum	17			5
Ascending colon	7		2	2
Hepatic flexure	6			5
Transverse colon	12	11	4	7
Splenic flexure and descending colon	10	10		10
Sigmoid	35	34	10	22
Rectosigmoid	11	9	1	8
Rectum	69		44	28

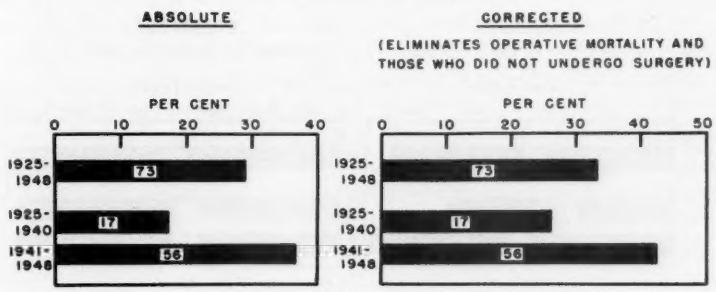

FIG. 13

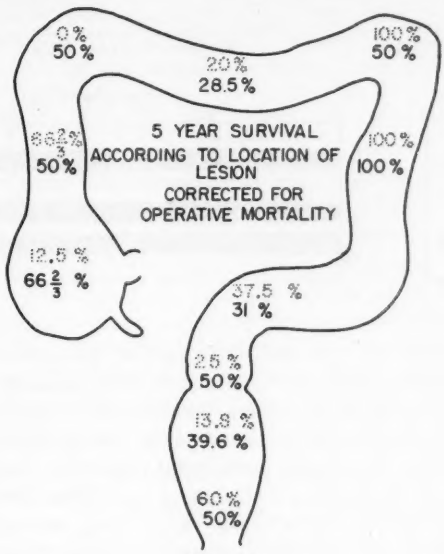

FIG. 14

RESULTS

The absolute 5 year survival for the entire series was 29 per cent. For the early period it was 17 per cent and for the later period it rose to 36.6 per cent. There are many factors that may alter these absolute figures. If one eliminates that group that had no surgery and those who did not survive operation, both of which compose a higher percentage of the early period, there is less difference in the 5 year survival percentages (fig. 13). If these patients are not counted, the 5 year survival in the early period rises to 26 per cent and in the late period to 42.4 per cent. The 5 year survival rates for both the early and late periods under the preceding conditions are demonstrated according to the location of the lesion in figure 14.

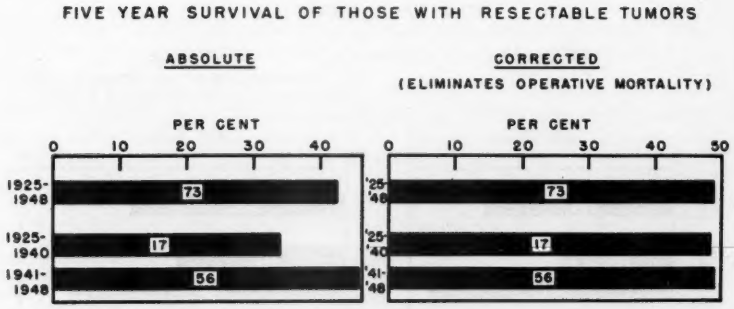

FIG. 15

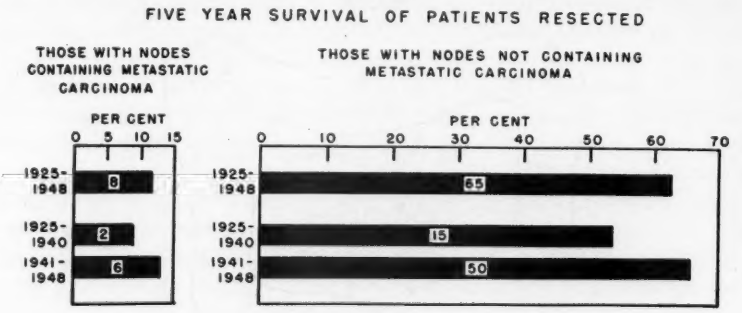

FIG. 16

We find that in the early period 34 per cent of the patients with resectable tumors survived 5 years, whereas, 46 per cent of the patients in the late group with resectable tumors survived 5 years. By eliminating the operative mortality, which is considerably higher in the early group, and considering the resectable lesions only, it is found that, given a resectable tumor and an operative survival, the chances for a 5 year survival were nearly as good in the early period (48.5 per cent) as in the late period (49.1 per cent). Thus, the improvement in the late group was due to lowering the operative mortality rate (fig. 15).

Figure 16 shows that in the early group only 2 of 22 patients who had metastatic carcinoma in the lymph nodes survived 5 years (9 per cent) and in the late group only 6 of 46 such patients survived 5 years (13 per cent). Of the resected tumors in which the lymph nodes were free of tumor microscopically, the 5 year survival rate was 53.6 per cent in the early period and 65.8 per cent in the late group. Of the 8 five year survivors with carcinoma showing metastasis to the lumph nodes, only 3 are living and well today—all 3 having been operated upon between 5 and 6 years ago. Four died of cancer after 5 years and 1 died of an unrelated condition. None of the 5 year survivors who had carcinoma of the cecum, ascending colon, hepatic flexure, sigmoid flexure, or descending colon have died subsequently of their original carcinoma.

One of the 5 year survivors in whom excision of the transverse colon was done died 12½ years after operation of recurrence and metastases from the original

tumor. One of the 5 year survivors who had carcinoma of the rectosigmoid died of metastatic carcinoma 5½ years following primary resection. Eight of the 5 year survivors who had rectal carcinoma eventually died of metastatic carcinoma and 4 patients with sigmoid carcinoma survived 5 years but subsequently died of metastases from their original tumor.

Only 2 patients, 1 with rectal and the other with transverse colon carcinoma, died of the original cancer after 10 years. The former died 10¾ years and the latter 12½ years after operation. Pulmonary metastases were found in 11 patients. Each of 5 patients subsequently was found to have a separate large bowel carcinoma but only 1 of them had both carcinomas within the period of time in which this study was made.

Of the 5 year survivors of large bowel carcinoma 4 subsequently developed primary carcinoma of other organs and 3 of these died of the second cancer (prostate, bile duct and cervix uteri). One patient is living and well following surgery for carcinoma of the breast. Another 5 year survivor subsequently developed myelogenous leukemia.

COMMENT

There has been slight improvement in early diagnosis of carcinoma of the large bowel at Vanderbilt University Hospital when the early group is compared with the later group. There remains a real need for both patient and physician education in the symptoms of this disease. The single most important diagnostic aid is the digital rectal examination. There can be no question but that the earlier the diagnosis and treatment the more favorable the prognosis. The findings in this report of the high incidence of obstructive symptoms and signs, radiographic evidence of obstruction and the gross pathologic findings of obstructing lesions in the right colon tumors exclusive of the cecum do not support completely the axiom that right colon lesions bleed and left sided tumors obstruct. It appears that all carcinomas of the large bowel, regardless of the specific location, show a marked tendency completely to encircle the bowel wall. In those areas of the large bowel, the cecum and the rectum, where there is a normal dilatation, obstructive symptoms were uncommon. However, the remainder of the large bowel does not vary greatly in circumference and mechanical obstruction apparently has no predilection for one segment or the other. The hematologic findings indicated that anemia was not conspicuously consistent with any particular location of the tumor.

An attempt was made to find the reason for the improved operative mortality rate in the late group of patients over the early group. The improvement began long before penicillin and streptomycin were available and the study actually ended before broad spectrum antibiotics were in common usage. Whole blood transfusions were given more generously in the late group, as were dextrose and saline, but protein hydrolysates and refined electrolyte solutions were not given to any of the patients in the late group. Gastric deflation by tube was effected almost exclusively in the late group, as was small bowel intubation. The sulfonamides were available in the late group but were not used routinely until

several years after the improvement in operative mortality began. A large percentage of the operations were done by a select group of surgeons in the early and late periods. Perhaps they were simply better surgeons in the later years. Certainly, the extremely low survival rates for those patients with lymph node metastases shows the need for a wider excision of the tumors and lymph node bearing areas.

SUMMARY AND CONCLUSIONS

The cases of large bowel carcinoma seen at Vanderbilt University Hospital from 1925 through 1948 have been reviewed. The cumulative data from these cases have been recorded.

In recent years patients seek medical advice for carcinoma of the colon slightly earlier and the first physician consulted sends them for definitive treatment with slightly less delay.

Increase in the percentage of 5 year survivals in the later years of this study is due to reduction in the operative mortality.

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TWENTY-FIVE YEARS OF PROGRESS IN INTRAVENOUS UROGRAPHY

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One of the outstanding addresses given at the inaugural meeting of the Southeastern Surgical Congress was that delivered by Dr. Joseph F. McCarthy of New York City on intravenous urography, a newly discovered diagnostic procedure. The honor given to me of reporting on 25 years of progress in the field of intravenous urography is deeply appreciated. This honor I humbly accept in the name of my late chief, Dr. Edgar Ballenger, the first president of this Congress and a longtime close friend of Doctor McCarthy whose health prevents his being with us today. In a recent communication he bids me extend to all of you his greetings and best wishes.

The roentgenographic visualization of the urinary system after intravenous injection of an opaque substance was the culmination of much work both in this country and abroad. This accomplishment ranks with other great milestones in the progress of urology. The invention of the first practical cystoscope by Nitzi in 1879 followed by Guyon's use of the newly discovered roentgen ray in diagnosis of urinary calculi in 1896, and the development of retrograde pyelography by Von Lichtenberg in 1906 all were great steps that afforded opportunity for accurate diagnosis in the field of urology in a scientific, orderly manner. The successful accomplishment of excretory urography in 1929 by Swick and Von Lichtenberg added a diagnostic measure that has fairly revolutionized diagnosis of urinary disorders. The history of the development of intravenous urography is most interesting. As early as 1923 Rowntree of the Mayo Clinic obtained visualization of the urinary tract by administration of oral and intravenous sodium iodide. The large quantities of iodide necessary for urography caused severe reactions in most patients. This work was repeated by others with similar unsatisfactory results.

Roseno in 1928, using a combination of urea and sodium iodide, was able to demonstrate more satisfactory excretory urograms but this compound also was found to be too toxic for safe use. In 1929 the discovery of uroselectan was made and its use announced by Swick and Von Lichtenberg of Berlin. This compound was demonstrated to be readily soluble in water and to be excreted in such concentration by the kidneys as to afford excellent visualization of the urinary tract. The amazing results of this discovery were far reaching since urologists and internists had long wished for such a discovery. The description of uroselectan along with a demonstration of its use in diagnosis of various renal lesions was Doctor McCarthy's theme before this Congress in 1931. The prediction then

From The Ballenger-McDonald Urology Clinic, Atlanta, Ga.

Presented during the Silver Anniversary Assembly of the Southeastern Surgical Congress in Atlanta, Georgia, February 21–24, 1955.

made by Doctor McCarthy that intravenous urography would prove to be of major importance in urologic diagnosis has been amply fulfilled.

During the past 25 years continuation of the search for less toxic iodine compounds has met with success. Also newer compounds have been found which are excreted in greater concentration and with much clearer delineation of the urinary tract.

Uroselectan was marketed in this country under the trade name of Iopax. It first was administered, as 10 to 15 Gm. in 100 cc. of distilled water, given intravenously. A short time later neo-iopax was introduced and more concentrated solutions in smaller amounts were used. Later improvements in iodine compounds gave us skiodan and neo-skiodan. The common denominator of all these substances was that they contained large quantities of iodine held in a stable combination and thus were relatively nontoxic if administered intravenously. Until the last five or six years neo-iopax and neo-skiodan, also called *diodrast*, were the chief agents used for excretory urograms. About 1948 an improved compound which was called urokon sodium was brought out and became quite popular as the agent for excretory urograms. Urokon has proved to be low in toxicity and the rapid rate of excretion as well as the high concentration of the substance by the normal kidney were factors leading to its wide acceptance and use for excretory urography.

During the past year another compound called hypaque has been brought out and early results are quite promising. On the basis of limited clinical use, hypaque affords urograms of high diagnostic quality and apparently is the least toxic of any of the media now in use. With improvements of Roentgen ray machines and new technics it seems likely that many more positive diagnoses may be made by means of excretory urograms than formerly was possible (fig. 1).

During the past 25 years improvements have been made in radiologic equipment that have added materially to the excellence of the urograms of today. Among these improvements are the improved rotating anode (Roentgen x-ray) tube allowing for more uniform exposure, and the new type reciprocating Bucky diaphragm. With the new reciprocating Bucky the grid constantly is in motion;

Routine Preparation

1. Castor oil 2 oz. at bedtime
   If unable to take castor oil 2 Gm. each of compound licorice powder and heavy magnesium oxide in ½ glass of water may be taken.
2. Nothing by mouth, *including liquids* for 12 hours prior to roentgenogram.
   Infants may be given formula 30 min. before urograms are to be made. No routine laxative.

FIG. 1

hence no grid lines ever are visible on the roentgenogram. Improved cassettes and intensifying screens have added to the clarity of modern roentgenograms as compared to those of a quarter of a century ago.

Increase in generator power of Roentgen ray machines and auto-timing devices now allow uniformity of technic not obtainable in former years. The efficiency of the modern Roentgen ray apparatus, as compared to that of 25 years ago, is much the same as a comparison of the automobile of today and the automobile of 1930.

Preparation of the patient was not understood at first to be of such great importance as it has come to be recognized today. The need for complete removal of all intestinal contents has been almost uniformly accepted in recent years. The *second best* laxative demonstrated in a large series of tests is 2 Gm. each of compound licorice powder and heavy magnesium oxide in a half glass of water taken at bedtime on the day before the urograms are to be made. The *very best* laxative to accomplish the desired results is 30 to 60 cc. of castor oil taken 10 to 12 hours prior to the time roentgenograms are to be made. The superior urograms obtainable after castor oil preparation are well worth the insistence needed to induce the average patient to take it. Other laxatives such as milk of magnesia, various cascara or senna compounds, saline purges or enemas are much less effectual and really appear to cause more obscuring gas shadows in many instances than no preparation at all (fig. 2).

An important discovery regarding preparation of infants was reported three or four years ago. It was demonstrated that the gas shadow of a full stomach usually pushed the confusing shadows of gas in the small intestine and colon downward and away from the area of the left kidney. Hence for nursing babies a bottle of the usual feeding formula given before the urograms are made causes the stomach to distend with gas and as a rule affords excellent visualization of the left renal pelvis and upper ureter.

In preparation of the patient for urograms, dehydration by avoidance of all

Media Used in Excretory Urography

1. Sodium Iodide (Rowntree 1923)
2. Sodium Iodide
   combined with Urea (Roseno 1928)
3. Uroselectan (Iopax)
   (Swick and VonLichtenberg 1929)
4. Uroselectan B (Neo-Iopax) (1931)
5. Hippuran (Swick 1933)
6. Abrodil (Skiodan) (1934)
7. Diodrast (Neo-skiodan) (1934)
8. Urokon Sodium (1948)
9. Hypaque (1954)

FIG. 2

Technic of Excretory Urography
(Usual Routine)

1. Preparation of Patient
   (Laxative and Dehydration)
2. Flat Plate or *scout film*
3. Injection of I. V. agent
   (Urokon, Hypaque or Diodrast)
   (Sensitivity test)
4. Exposure Sequence:
   Films made 5″, 10″, 10″ semi-erect, 15″, and 20″
5. Film of bladder area, angulation of Roentgen ray tube for bladder, prostate shadow.
6. Delayed films as need is demonstrated.

FIG. 3

A measure of renal function can be estimated by the promptness of the appearance of the excreted medium and by the concentration of the substance in the renal pelves. This concentration in the presence of mild obstruction may be misleading; hence proper interpretation must be given urograms that show evidence of such obstruction by increased density of the excreted iodine compound (fig. 3).

The use of compression bands or bags over the region of the lower ureters at times may afford a clear outline of the upper ureters and renal pelves but allowances for the kidney function must be made in the correct interpretation of urograms thus made.

An important discovery of recent years in regard to the renal function in the presence of ureteral calculus often was the delay in function observed on the side of the ureteral calculus. This delayed function can be demonstrated by taking films at 1, 2 or 3 hour intervals after the injection of the urographic medium. In some instances even 6 to 12 hours later the excretion will be shown on the affected side while the normal kidney will be seen to exhibit a normal rate of excretion. Delayed excretion of urographic media then has especial significance when it occurs unilaterally.

Excretory urograms also are of major importance in the diagnosis of vesical masses, bladder tumors, bladder diverticula and prostatic enlargements that protrude into the base of the bladder. The diagnosis thus made of such prostatic obstructing masses renders unnecessary preliminary cystourethroscopy in a large percentage of patients. The concentration of the medium excreted as well as the rate of excretion also has been found to be a satisfactory gauge of the renal function.

SUMMARY

The improvements in excretory urography over the past 25 years have been in the development of less toxic and more powerful media for visualization of the

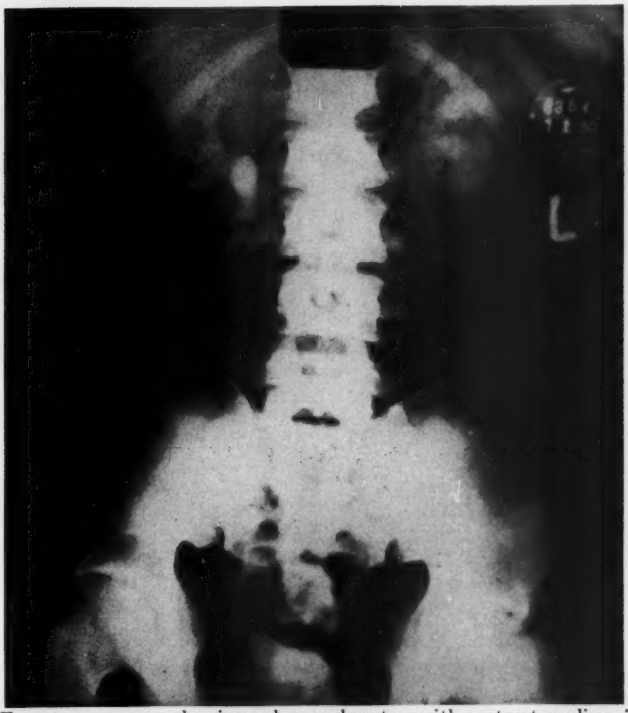

FIG. 4. Excretory urogram showing pelves and ureters with contrast medium in rectum, 12 months after bilateral uretero-intestinal anastomosis. Made in 1930 with Iopax.

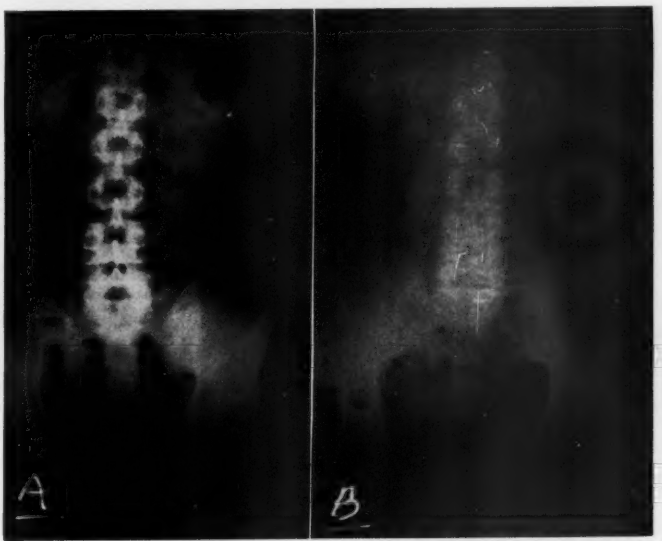

FIG. 5. Excretory urograms made in 1930 (A) (Iopax) and 1935 (B) (Skiodan).

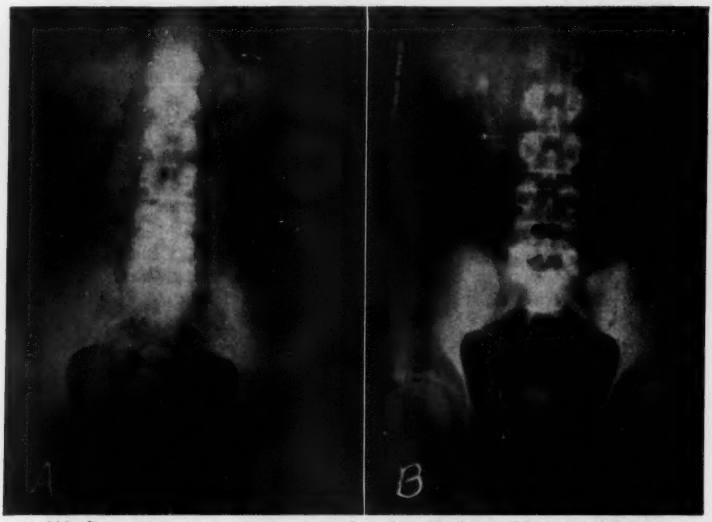

FIG. 6. (A) shows excretory urograms made using diodrast (New-skiodan) 1940 (A) and 1945 (B).

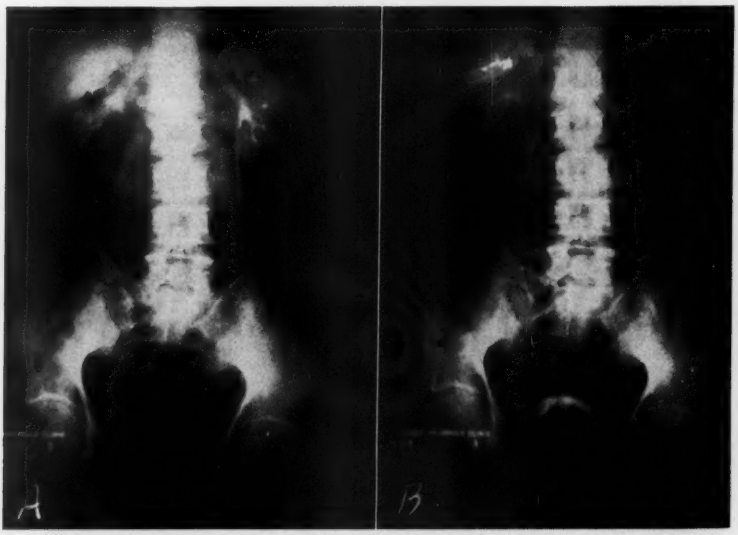

FIG. 7. Intravenous urogram using urokon 35 per cent (A) 5 minutes after injection and (B) 20 minutes after injection. Note shadow of prostate and calyceal diverticulum in right kidney.

liquids for 12 hours prior to administration of the intravenous agent has been shown to increase the density of the urographic shadow due to greater concentration of the contrast media during excretion.

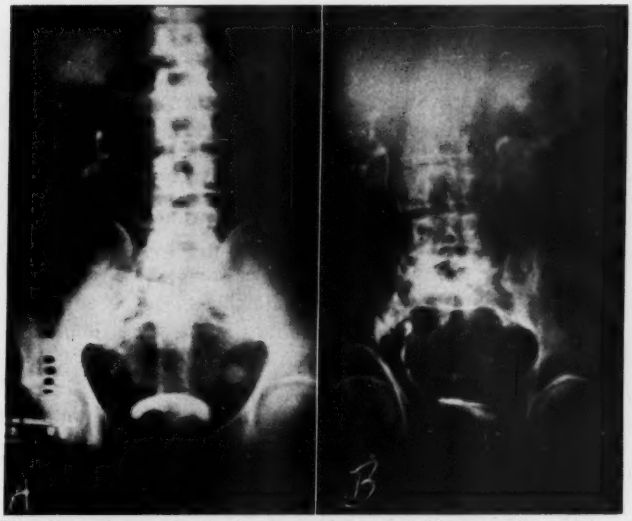

FIG. 8. Excretory urograms using hypaque 50 per cent. Note prostate shadow in (A) and ureteral detail in (B).

urinary passages. The roentgenographic equipment likewise has been greatly improved. The reciprocating Bucky diaphragm, the rotating Roentgen ray tube, improved timing and development devices have kept pace with new discoveries in media to be injected.

The interpretation of excretory urograms has become more exact and more often may be considered to be of diagnostic value than in the years past. Increased use of the excretory urogram as a preliminary diagnostic procedure has been of great benefit. Further increase in the use of excretory urography is anticipated and recommended.

A comparison of excretory urograms made 25 years ago and those made recently is offered to demonstrate the marked improvements mentioned. The pathologic processes that now are demonstrable approach the efficiency of retrograde pyelography of 25 years ago (figs. 4, 5, 6, 7, 8).

CONCLUSIONS

The marked improvements in results in intravenous urography during the past quarter of a century have been of great help in diagnosis of urologic lesions and diseases. New media have been discovered that have proved to be relatively nontoxic and to be excreted by the kidneys in sufficient concentration to give a high degree of radiopacity.

Improved technics and Roentgenographic equipment have allowed more accurate interpretation of far better roentgenograms. Continued increase in use of the intravenous urogram in routine complete examinations is recommended.

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THE RESULTS OF SURGERY FOR MITRAL STENOSIS

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In the past five years the modern operative treatment of mitral stenosis has become standardized as to technic and procedure. Thousands of patients, disabled by mitral stenosis, have accepted surgery at many medical centers throughout the world. Earlier impressions[4] concerning the efficacy of surgical treatment have for the most part been confirmed. We now are in a position to audit the results of the therapy; to assess its merits; to define its limitations, and to scrutinize its failures.

At this time we are able to analyze a series of 50 cases of mitral stenosis in patients upon whom we have operated and followed for a period of 12 months to more than 4 years.

RESULTS

In classifying the end result in these patients thus far, we have divided the living patients into four groups.

Group 1. In the first group, and the largest, we have designated the results as excellent. Twenty-four patients, or 48 per cent of those operated upon, fall into this group. We have used as the criteria for obtaining this excellent rating a complete rehabilitation of the patient. He does not require any cardiac medical therapy such as digitalis, diuretics, or salt restriction. These patients are working at their previous jobs or at occupations equally as strenuous. Two are able to work in coal mines. Two of the women subsequently have had uneventful pregnancies and deliveries.

It is our impression that there is no more satisfactory or dramatic therapy that the surgeon has to offer the sick than commissurotomy in a patient disabled by a pure mitral stenosis. The contrast of the situation before and after treatment is one of the most striking events that we have witnessed in surgical therapy.

Group 2. The second group we have designated as improved. On the basis of clinical judgement these patients are deemed to be better or somewhat better than they were preoperatively. They require continued medical supervision and treatment. Fifteen, or 30 per cent of the patients, fall into this group. All have an anatomic reason for their failure to obtain maximum benefit from the operation. In 2 patients there is an associated aortic lesion which has not been corrected. In 3 there is extensive calcification within the mitral leaflets which made complete surgical correction of the lesion impossible. One of these patients had repeated flare-ups of what apparently was rheumatic fever over a period of one year following surgery, and it was not until the end of this time that it was pos-

Presented during the Atlanta assembly of The Southeastern Surgical Congress, Feb. 21–24, 1955.

sible to classify her as improved. The remainder of the group have an associated mitral insufficiency.

Group 3. The third group of 8 patients we have classified as unimproved. These patients constitute 16 per cent of the group. They have an anatomic reason for their failure to obtain improvement. Three of the 8 patients have extensively calcified valve leaflets and auricles, or both. In 4 there is a dynamically important degree of associated mitral insufficiency. In 1 patient there is an associated large atrial septal defect which has not been repaired.

Group 4. The 1 patient that we have deemed worse after operation is a patient who was disabled by exertional dyspnea so that he could no longer do his usual work as a tree surgeon. At operation this patient had a tight mitral stenosis with an associated insufficiency which was not thought to be dynamically important. After a wide opening of his partially calcified anterolateral commissure the insufficiency was increased. During the 12 months that he has been followed postoperatively he has required strict medical supervision and frequent administration of diuretics to control ankle edema. Preoperatively edema was minimal and required infrequent medication. His exercise tolerance has not been increased and we believe that his status is worse than before surgery.

ANALYSIS OF DEATHS

In this operative series there were no deaths in the operating room. There were two deaths within the period of hospitalization. One of these deaths was caused by a cerebral embolus on the third postoperative day. The other was the result of a myocardial infarction in a patient who had an associated aortic stenosis and insufficiency. Death occurred on the sixth postoperative day. We believe that this operative mortality rate of 4 per cent is lower than is reported in most series.

Embolic Complications

Our incidence of fatal emboli has been extremely low, but we have no explanation for this other than good fortune. We have used digital compression of the neck vessels as suggested by Harken[2] and also have used the method of kinking the great vessels by means of a surrounding tape as suggested by Bolton,[1] but only in patients with extensive calcification and/or thrombotic appendages. We are doubtful of the value of these maneuvers and we believe that they may in fact create just the situation one is attempting to prevent. There have been three nonfatal cerebral emboli in the series; two of these cleared without residua and a third patient was left with an homonymous hemianopsia. One patient, not in this group of 50 early operations, has survived after the successful removal of a saddle embolus from the aorta. A similar experience has been reported by Moore and Harris[3], with a review of the literature.

Late Deaths

In this series there have been six late deaths occurring four months to slightly over two years after mitral valve commissurotomy. One of these patients who was initially improved following mitral valve surgery died approximately two

years later on the operating table at another institution in the course of a proposed operation for mitral insufficiency. A second patient died 1½ years after mitral commissurotomy of complications following aortic valve surgery. A third patient died four months after mitral commissurotomy of progressive heart failure. This patient had extensive calcification of the mitral leaflets and also of almost the entire wall of the left auricle. There was an associated severe pulmonary emphysema. The fourth patient died nine months after operation of uncontrolled heart failure. This patient had an associated mitral insufficiency with extensive calcification of the mitral valve leaflets. He was not helped by his mitral valve surgery. We know that this patient had an inoperable type of mitral stenosis, but we were not able to recognize that condition in the light of our knowledge at the time of that operation. A fifth patient died one year after commissurotomy of progressive uncontrolled heart failure due to associated mitral insufficiency. We do not believe that the mitral insufficiency was increased at the time the commissurotomy was done. A sixth patient died 11 months following operation from progressive uncontrolled heart failure. This patient had extensively calcified mitral leaflets and was not helped by his operation. There was an associated mitral insufficiency which possibly was increased by the commissurotomy.

Inasmuch as we have elected to place only 1 postoperative patient in the group made worse by surgery, it might be argued that four of these late deaths should have been placed in the same group. We have not done so, inasmuch as clinically we could not judge that the patient was any worse after surgery. The 4 patients were all in group four. They were bedridden with cardiac disease preoperatively. They were able to be discharged from the hospital and survived 4, 9, 11, and 12

FIG. 1

months after the operation and did not appear worse during this period than they had appeared preoperatively.

Even a superficial analysis of these patients and their results makes it obvious that it is *the anatomic status of the mitral valve* which is the most important single determining factor in the patient's operative result. The patients with pure mitral stenosis with little or no valvular calcification routinely obtain excellent results. With associated insufficiency and more extensive calcification the result may be slightly improved, unimproved, or worse. Certainly the most extreme degrees of calcification constitute an inoperable type of mitral stenosis (fig. 1). It would be helpful if these inoperable lesions could be recognized preoperatively. It may be possible to eliminate these patients by a careful correlation of laminagrams of the heart with the findings at surgery and the postoperative result.

We hope to eliminate patients in whom mitral insufficiency is the most important disabling lesion by transbronchial pressure determinations in the left auricle. If one believes that there is at the present time no satisfactory operation for mitral insufficiency then this technic assumes considerable importance.

DISCUSSION

In any discussion of surgical treatment of mitral stenosis certainly it is of some importance to know whether the author is discussing surgery for patients who have no disability, patients who are slightly disabled, or patients who are severely disabled. The classification of the American Heart Association therefore is of importance for this purpose.

Classification of these patients preoperatively into groups according to their degrees of disability reveals that none of our patients in group one have been operated upon. Five of the patients fall into group two. Twenty-four patients are in group three and 21 patients in group four.

Evaluation of improvement according to groups is of less importance and offers statistical information only. A correlation of the anatomic lesion with the degree of improvement is more enlightening. It has been our experience that all patients operated upon were improved except those with an associated anatomic lesion such as extensive calcification with immobile valve cusps, or other patients who had dynamically important mitral insufficiency and/or associated lesions of other valves. It would seem that hopes for improving the percentage of good results in the surgical treatment of mitral stenosis would depend upon eliminating these patients from surgical treatment. It would be particularly helpful if one were able to eliminate the small group (6 per cent in our series) who have such extensive calcification and fixation of the mitral valve leaflets that no benefit can be expected from opening the fused commissures. Pathologists who have viewed this type of specimen at postmortem have been inclined to question the entire concept of mitral valve commissurotomy. These specimens are inoperable on the autopsy table and are likewise inoperable at the operating table.

SUMMARY AND CONCLUSIONS

End results in the first 50 patients operated upon for mitral stenosis are reviewed and analyzed.

Complete rehabilitation, or marked improvement, occurred in 78 per cent of the patients in this series.

Unsatisfactory operative results are correlated with the pathologic anatomy of mitral valve disease.

An inoperable type of mitral stenosis is recognized and described.

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DANGERS AND MANAGEMENT OF RETAINED TRACHEOBRONCHIAL SECRETIONS

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Louisville, Ky.

Even in this day of modern medicine physicians still see many patients gradually deteriorate, lapse into coma, develop the familiar *"death rattle"* and finally die, having literally drowned in their own tracheobronchial or aspirated pharyngeal secretions.

We now are beginning to realize that a frequent but unrecognized complication of many of the conditions we meet in our daily practice is obstruction of the airways by accumulating tracheobronchial secretions. Resulting asphyxia is the direct but insidious cause of many of the grave symptoms—and often death—commonly but mistakenly attributed to the underlying disease. Prompt recognition of this entity and immediate institution of proper therapy prevents an otherwise inevitable death or places the patient in a better physiologic status, by correcting the hypoxia, to combat his primary disease. It, therefore, behooves us to be aware that such an entity exists, be able to recognize it and immediately institute proper therapy.

ETIOLOGY

The glands of the tracheobronchial tree normally secrete a thin, mucoid material to combat the drying effect of air and to aid in cleansing of the tree. Normally, this secretion is eliminated by ciliary action of the respiratory mucosa and by cough. If anything interferes with this elimination, e.g., impairment of the cough reflex or ciliary action, these secretions dam up with resulting obstruction of the airway, atelectasis, hypoxia, pneumonia and, if not corrected, death (fig. 1).

The more common factors responsible for excessive tracheobronchial secretions and their retention are: (1) aspiration of oral and pharyngeal secretions, commonly seen in the weak, debilitated patient, (2) chronic bronchitis (often secondary to heavy smoking) and mild bronchiectasis, (3) inability, insufficient strength, or unwillingness of the patient to cough effectively and expectorate, (4) lack of application of successful measures to aid cough and expectoration, (5) unconsciousness of patient as with too heavy preoperative and postoperative narcotics, anesthetic agents and coma or comatose states, (6) ineffectual cough due to pain or tight abdominal binders, (7) tenacious secretions too thick to be expelled except by effective cough, (8) paradoxical motion of chest or mediastinum as with thoracoplasty, multiple rib fractures and sucking wounds of the chest, (9) semi-Fowler's position which favors collection of secretions in bases of the

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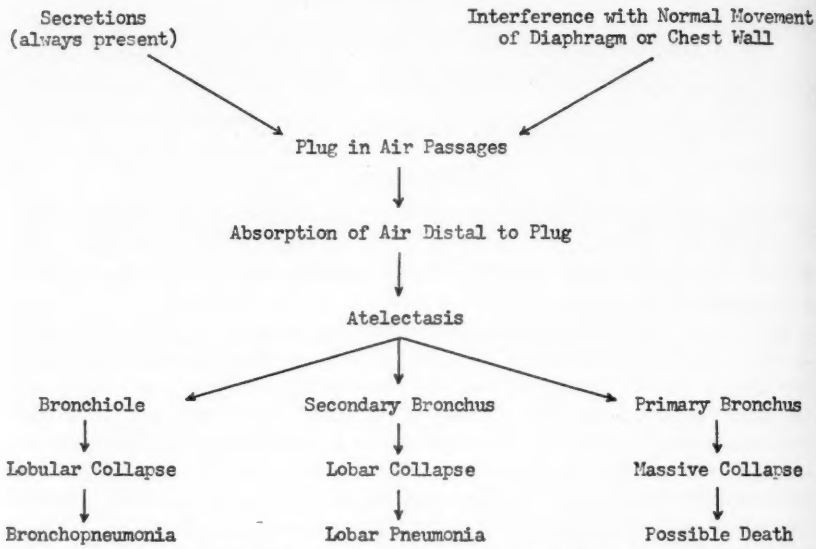

FIG. 1. Diagram of effect of retained tracheobronchial secretions on lung.

lungs, (10) atelectasis which, in itself, is prone to stimulate viscid bronchial secretions.

DIAGNOSIS

Impending atelectasis or definite atelectasis as a result of retained tracheobronchial secretions should be suspected and immediately eliminated in any sudden rise in temperature, pulse or respiratory rates, particularly in postoperative patients. The most important symptom is a relatively unproductive, wet, "*rattly*" cough. With more advanced bronchial obstruction varying degrees of dullness, diminished breath sounds and fremitus usually are present. The presence of rhonchi by stethescope usually is a late or pneumonic expression of retained secretions.

The presence of tracheal rales and a wet type of breathing audible to the naked ear, often called the death rattle, indicate a serious retention of secretions.

Roentgenograms often are of great help and should suggest retained secretions if the lungs appear poorly aerated and certainly if definite atelectasis of any extent is demonstrated.

PROPHYLAXIS AND TREATMENT

Prophylaxis is based on the control of the production of the tracheobronchial secretions, and once formed, their removal as quickly as possible. Voluntary cough is the most important mechanism of prevention, and appreciation of this by all who come in contact with the patient is one of the most important steps towards successful prophylaxis.

We have found it very helpful in all patients in whom we expect future difficulty with retained secretions, e.g., heavy smokers, to carefully explain the need of coughing and to train them to cough vigorously, particularly in any patient who is being prepared for major surgery. During major surgery an endotracheal tube is almost routinely used to facilitate aspiration of secretions as well as to administer the anesthetic, and, before the patient is removed from the table, all pharyngeal and tracheobronchial secretions are thoroughly removed by catheter aspiration through the endotracheal tube or, rarely, bronchoscopy.

Postoperatively, a vigorous stir-up, with cough and aspiration routine is employed, directed at the control of formation of excessive secretions, and, if formed, their removal as quickly as possible. The patient is strongly encouraged to cough effectively at least every hour during his first 24 to 48 hours and at gradually increasing intervals thereafter until all danger has passed. At the same time, his position is changed, side to back and back to side. As soon as possible, usually within 24 hours, the patient should be gotten out of bed 15 to 20 minutes, four times a day, and encouraged to walk around his bed and room.

The following aids to cough often are of great help and should be used to facilitate the cough: (1) several deep breaths just prior to coughing, (2) a little swallow of water just prior to coughing, (3) support of the operative incision during the coughing either by the attendant or the patient himself, coughing 15 to 20 minutes following postoperative sedation, and (4) have the patient sit up while coughing. In giving narcotics take care not to give so much as to actually depress the cough reflex or make the patient so drowsy as to be uncooperative in his stir-up regime. Morphine is the worst offender in this respect and for this reason we seldom use it.

Inhalation of high humidity atmosphere 20 to 30 minutes, three or four times daily, is helpful in thinning or preventing drying of the secretions and thus making them easier to cough up. Ammonium chloride, in 1 gram doses every 2 to 4 hours, also is very helpful in this respect. The doctor, nurse and attendants must not let their sympathy deter them from seeing these things done, as it may mean the difference between life and death of the patient.

In spite of the aids mentioned, we still have many patients who are unable to effectively raise their secretions. Prompt removal of these secretions is indicated as soon as it is evident that the cough is ineffectual and tracheobronchial secretions are being retained.

The best and most effective method of removing these secretions is bronchoscopy; however, this requires special equipment and an experienced operator, neither of which can be had on short notice in many localities, particularly our smaller cities and hospitals. Serious consequences and even death may well result while the services of a bronchoscopist are being awaited. It is no longer absolutely necessary to call a specialist to take care of these secretions by bronchoscopy and thus lose valuable time, and possibly the patient, while waiting for him to arrive. The method I would like to describe has been thoroughly reviewed and discussed by Haight[5, 6, 7] and Cardom,[2] and is one that can be learned quickly by any physician and often by the nurse. It requires only equipment found around

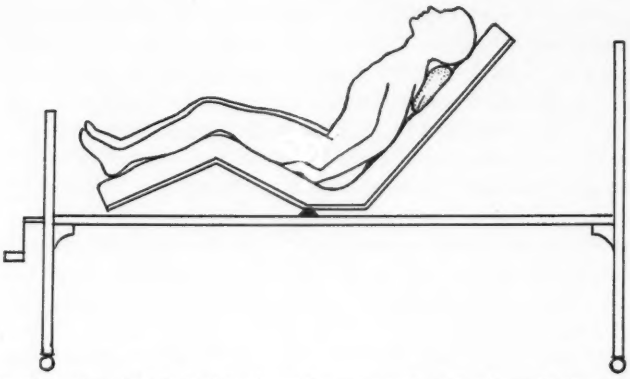

FIG. 2. Position of patient in bed for bronchoscopy and tracheobronchial catheter aspiration.

any hospital and in many physicians' offices, and can be readily repeated on short notice.

The equipment needed for intratracheal aspiration consists of: (1) a no. 16 or 18 new French urethral catheter with an extra hole cut in the side about 2 cm. from the tip (a much better catheter consists of a no. 16 or 18 regular rectal tube which is 4 inches longer and the holes are already cut and in better position), (2) four or five feet of rubber tubing for connection of the catheter to the suction source, and (3) a suitable suction source that quickly develops 15 to 20 pounds of negative pressure. Of great help, but not absolutely necessary, is a Y glass tube or Lukens' tube interposed between the catheter and tubing leading to the suction machine. This enables the physician to more easily apply intermittent suction, but the same effect may be obtained by pinching the tube as necessary. We have, on occasion, found 1 per cent pontocaine applied to the pharynx helpful in eliminating an, at times, rather troublesome gag reflex that occasionally interferes with introduction of the catheter.

The patient, if possible, is placed in a semi-Fowler position with a pillow beneath the shoulders, the neck moderately flexed and the head extended on the neck (fig. 2). He then is asked to protrude his tongue, which is grasped with the thumb and forefinger of one hand over a dry sponge, and with the other hand the lubricated catheter is inserted through the naris and into the pharynx down to the larynx. He then is asked to cough and the catheter is quickly advanced into the larynx during the inspiration immediately following the cough. The catheter also may be introduced during any inspiratory phase of respiration if he is unconscious or is unable to or will not cough. As soon as the tip of the catheter enters the trachea the patient becomes aphonic, usually goes into a rather severe coughing spasm and immediately starts bringing up the secretions either around the catheter or to the end of the catheter where they are quickly aspirated. He then is lowered into a recumbent slightly Trendelenburg position. Suction is applied through the catheter as it is advanced back and forth into the

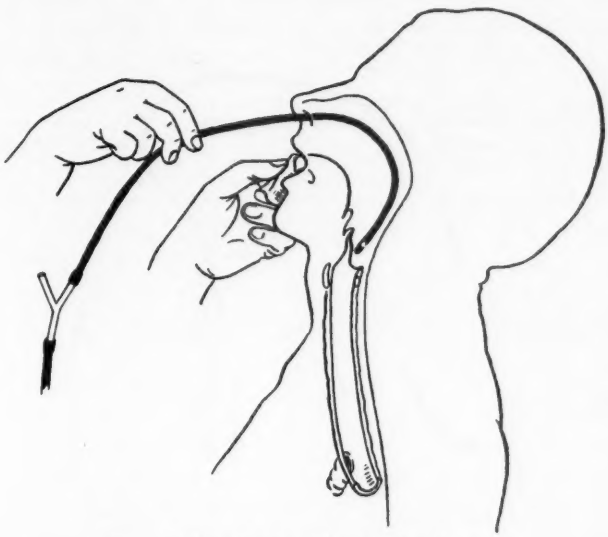

FIG. 3. Method of introduction of catheter.

bronchial tree in about 5 to 10 second suction periods until the tree is thoroughly cleaned out. The operator should be careful not to apply the suction too long as he may possibly asphyxiate the patient or markedly increase his discomfort. One should also give the patient sufficient time between each suction period to catch up on his breath. The catheter can be directed with ease into either tree by turning the head from side to side (fig. 3, 4).

One of the most valuable assets of the catheter is its psychologic value in encouraging the patient to make stronger efforts to raise his secretions in order to avoid further catheter aspirations.

If bronchoscopy or catheter aspiration prove inadequate for aspiration of the secretions or are required repeatedly, for example in those instances of serious head injuries or respiratory paralysis, tracheostomy should be done.

Tracheostomy should no longer be considered only a desperation last resort emergency measure for relief or to by-pass a high respiratory obstruction. Its value in improving respiratory exchange by decreasing the respiratory dead space, decreasing the resistance to air flow at the glottis and in providing a readily accessible passage for aspiration of retained tracheobronchial secretions, as worked out experimentally and clinically by Carter,[3, 4] now place it in the repetoire of elective procedures that may be used as prophylaxis and treatment of impending or serious pulmonary pathology.

Any patient in whom we expect prolonged difficulty with retained secretions, e.g., serious head injuries, severe crushing wounds of the chest, and respiratory paralysis, now almost routinely has a tracheostomy at or very shortly after admission as part of his immediate admission therapy.

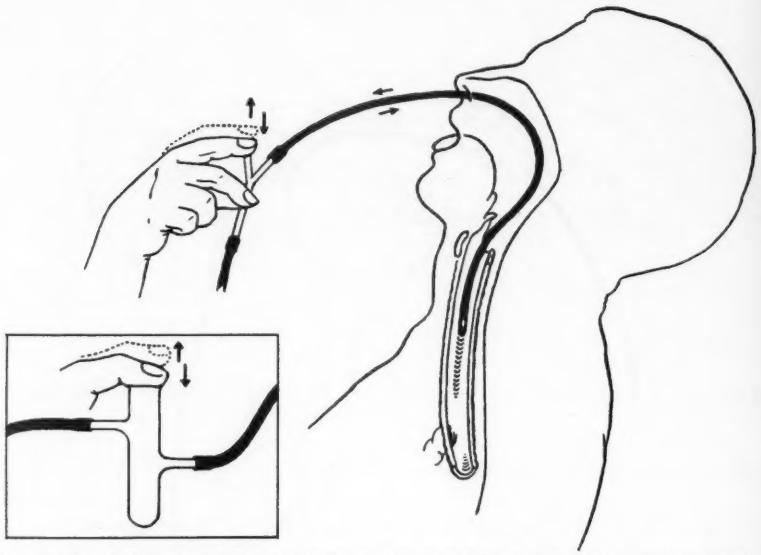

FIG. 4. Illustration showing use of Y glass tube and Lukens tube in tracheobronchial aspiration.

Any patient that is requiring bronchoscopies or tracheobronchial catheter aspirations repeatedly or does not show marked improvement within a few hours by these measures is immediately considered a candidate for tracheostomy to obtain control of these secretions. Other measures that may be of great help, but which unfortunately require rather expensive specialized equipment, are the production or simulation of cough proposed by Barach[1] by a combination respirator and exsufflator machine and the use of intermittent positive pressure reinforcement of inspiration as obtained by the Bennett valve or Bennett machine[8] and possibly by use of the closed mask technic with an anesthesia gas machine.

SUMMARY

The dangers of retained tracheobronchial secretions are reviewed.

The more common causes of retention of secretions are listed.

The prophylaxis of retention of secretions and the use of bronchoscopy, catheter and tracheostomy in aspiration of the retained secretions are reviewed.

Hardly anything is more gratifying than to see a cyanotic moribund patient with the familiar "*death rattle*" within 10 to 15 minutes following proper aspiration of the tracheobronchial secretions clear the cyanosis, reaerate his lungs, return to consciousness and quickly start on the road to recovery from an apparently hopeless situation. This is not at all an unusual sequence of events seen with thorough aspiration of retained tracheobronchial secretions.

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SPONTANEOUS RENODUODENAL FISTULA*

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Spontaneous renoduodenal fistula is a relatively uncommon entity. These fistulas usually are caused by an inflammatory process in the region of the kidney and associated viscera. Fistulas are classified according to the point of origin and termination. When fistulas develop in the kidney or perinephric space, they are classified as renovisceral, i.e., renogastric, renoduodenal, renocolic, or renopulmonary. The point of origin may be in a neighboring organ and terminate in the renal parenchyma. In such cases, the usual anatomic designation is reversed, i.e., gastrorenal, duodenorenal, or appendicorenal.

Rayer's[14] report of a case of Campaignac in 1839 is the earliest record of a spontaneous duodenorenal fistula. This was due to a right perinephric abscess secondary to a right pyonephrosis and right ureteral stone as shown by autopsy. Perry and Shaw[12] cited 2 cases, one was Barlow's due to a hydatid cyst of the right kidney which had eroded the duodenum. The other case was Turner's which was due to pulmonary and renal tuberculosis with fistuous tracts between the kidney pelvis and duodenum. These cases were proved by autopsy. Bang[3] and Pulvertaft[13] each reported a case due to tuberculosis. Abeshouse's[1] review of the literature on renal and ureteral fistulas recorded 5 additional cases. These are listed as follows: Thirias[16] and Esau[7] each reported a case due to primary perinephritic abscess; Hinton[8] and Terebinski[15] each reported a case due to calculous pyonephrosis and Arendt and Brockman[2] reported a case due to hydronephrotic pelvis. Biondi[4] reported a case due to a perforated duodenal ulcer. King[9] reported a case due to a pyelonephritis and perinephritis.

Duodenal renal fistulas caused by foreign bodies, i.e., hairpins, are reported by Blaine,[5] Capon and Wills,[6] McEnery and Fox,[11] and Mackby.[10]

CASE REPORT

Mrs. G. W. P., a 59 year old white woman, was admitted to another hospital two years ago, where she was treated for a urinary tract infection and calculi. Surgery was advised, but was not accepted. After leaving the hospital she had no further frank attacks of ureteral colic on the right side. She did have some dull aching pains in the region of the right kidney associated occasionally with pain referred along the right ureter.

Approximately two weeks prior to admission to the Wayne County Memorial Hospital she developed severe, acute pain in the right upper quadrant of the abdomen, which radiated posteriorly to the region of the scapula. This pain was associated with nausea, vomiting, elevation of temperature and repeated chills. She was seen and treated by her local physician for an acute cholecystitis. She treated herself at home for approximately 10 days and was not seen again by her physician.

The pain continued and she became acutely tender in the right upper quadrant. She ad-

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FIG. 1. Dye is seen partially filling the right renal pelvis and spilling into the duodenum. Several opaque stones are present in the renal pelvis and calyces.

mitted having indigestion following meals for the past several years. She had an intolerance to greasy foods and had considerable flatulence following meals.

Physical examination showed an acutely ill, well preserved, white woman. Positive findings were limited to the abdomen. There were no visible scars or tumor masses present. On palpation, there was exquisite tenderness over the gallbladder region, associated with marked muscle spasm. There was a sensation of a tumor mass felt on bimanual palpation.

The impression was right nephrolithiasis, chronic pyelocystitis and acute cholecystitis.

Laboratory findings showed the following: Urinalysis, albumin 1 plus, 12 to 15 granulocytes, a few erythrocytes and an occasional hylain cast. White blood count 11,800 per cu.mm, red blood count 4.4 million per cu.mm., hemoglobin 85 per cent, neutrophils 79 per cent, lymphocytes 20 per cent and eosinophil 1 per cent.

Roentgenograms following injection of Priodax showed no dye in the region of the gallbladder and no opaque stones were seen.

A retrograde pyelogram showed several large opaque calculi in the region of the right kidney. Opaque dye was injected through the catheter and filled the renal pelvis, but not all of the calyces. Dye was seen spilling into the duodenum. The left kidney appeared

normal. A repeat retrograde pyelogram, again, showed the renoduodenal fistula (fig. 1). Roentgenograms of the upper gastrointestinal tract failed to demonstrate the fistula.

Under general anesthesia, a right lumbar incision was made and the following findings were noted. The kidney was much enlarged. There was evidence of a long standing inflammatory process with the kidney firmly adherent to the perirenal tissues, paravertebral muscles and so densely adhered to the parietal peritoneum that it could not be stripped free. After complete dissection of the kidney, it was found that the junction of the second and third portions of the duodenum were firmly adhered to the kidney just beneath the renal pelvis. The duodenum was dissected free and a fistula between the kidney and duodenum was demonstrated.

The gallbladder was enlarged and tense but stones could not be palpated. It emptied very poorly on pressure.

The kidney was removed. The duodenal fistula was closed by means of a purse string suture. The redundant parietal peritoneum was used to cover the denuded area and close the peritoneal cavity. A cigarette drain was inserted into the depth of the wound, and the wound was closed in anatomic layers.

The pathologic findings were a chronic pyonephritis with marked destruction of the renal parenchyma. Many calculi were present.

The patient had a surprisingly smooth postoperative course. There was a large quantity of serous drainage from the wound due to the inflammatory changes about the kidney site. There was no purulent drainage. The patient made an uneventful recovery and was discharged asymptomatic.

COMMENT

The right kidney was involved in all recorded cases except that of Arendt and Brockman where the left kidney communicated with the duodenum at its junction with the jejunum. The fistulous tracts were demonstrated by retrograde pyelograms. Upper gastro-intestinal roentgenograms demonstrated the fistula in only a few cases.

Treatment consists of nephrectomy and closure of the fistulous tract. A two-stage procedure is advocated when the local condition does not permit a nephrectomy at the initial operation. Closure of the fistula and drainage of the abscess is of primary importance.

SUMMARY

A case of renoduodenal fistula successfully treated by operation is reported with a brief review of the previously reported cases.

ACKNOWLEDGMENT

The author expresses his sincere appreciation to Dr. George R. Benton, Jr., and Dr. Walton H. Miller, Jr. of Wayne County Memorial Hospital of Goldsboro, North Carolina for making the record on the above case available.

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FRACTURES: REVIEW OF SOME METHODS OF TREATMENT

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Atlanta, Ga.

The chairman of your program committee reminded us that Doctor Michael Hoke and we had participated in the first meeting of the Southeastern Surgical Congress and invited us to have essentially the same subject to-day. The subject then was "Present Day Methods of Treating Fractures and other Orthopedic Problems."

It is remarkable how the various arts and sciences influence each other and how they progress simultaneously. Even in our own profession progress in one specialty influences the progress in others. Progress also may be made in a negative way by the influence of a contemporary specialty as when the myth of sacroiliac sprain was disproved by the discovery that this syndrome is attributable to protruding intervertebral disc. Departments of Public Health and Internal Medicine have so nearly eliminated tuberculosis that tuberculous hips and spines, which once constituted a considerable percentage of orthopedic problems, requiring surgery for spine and hip fusion, are a rarity today.

Osteomyelitis constituted a good part of our surgery until this disease was cured in its early stages by antibiotics. Now there is a minimum of chronic osteomyelitis. Chemistry has contributed much to bone and joint surgery, especially with regard to aseptic surgical technic, which has been so improved by the use of detergents such as Phisoderm, in perparation of the skin, that one has much assurance that there will be no infection. Metallurgical chemistry has rendered a valuable service to bone surgery by cooperation with Doctors Venable and Stuck, in their experimental study of electrolysis, caused by the use of metals of different chemical analysis. Organic chemistry has given us such drugs as My-B-Den and Cortisone, two drugs recently developed, which have almost specific curative effect in certain types of bursitis and arthritis.

About 30 years ago Doctor John B. Murphy of Chicago surprised readers of his quarterly publication by showing a picture of a fractured femoral neck being held in place by a 12 penny nail driven through the trochanter and neck and deep into the femoral head. A short time later, Doctor Smith-Petersen presented his history-making flanged nail. Doctor Wescott of Roanoke, Virginia devised a technic for placing the nail blindly. This innovation simplified and popularized the use of the Smith-Petersen nail so that in time it has become a standardized procedure. So pleased was everyone, that it was thought to be the final answer to the problem of femoral neck fractures, and it was the wish of all that the trochanteric fracture also might be taken care of in some similar way. The combination of Smith-Petersen nail and Lane bone plate was the answer. Innumerable types of nail plate combinations have been devised by ingenious surgeons and have given most satisfactory results.

Presented during the Atlanta assembly of The Southeastern Surgical Congress, Feb. 21–24, 1955.

At first it was thought that almost all of the femoral neck fractures would unite promptly and good results would be assured. However, there was much disappointment when statistics later showed that aseptic necrosis and nonunion occurred over the world in about the same percentage as by the old Whitman plaster cast method. There then was a demand for ways and means of prevention and salvage. Imperfect settings and too early weight bearing seem to be the most frequent causes of this failure.

Doctor James A. Dickson of Cleveland stressed the importance of early recognition of impending failure and advised renailing with femoral head placed in a more advantageous position on the reshaped femoral neck, plus bone grafting across the fracture line.

Doctor Phemister of Chicago, for years studied the life story of bone cell growth with special reference to healing of fractures of femoral neck. It is believed that if the principles learned by his study were regarded aseptic necrosis and nonunion of the femoral neck would be minimized nearly to the point of complete prevention.

Metal and plastic prosthesis or artificial heads have been used promiscuously for replacement of damaged heads. It is a valuable procedure for very old people whose life expectancy is short and for some very badly damaged heads. Its use is contraindicated in those of younger age. After sacrificing the head and neck and applying the artificial head there remains little more that could be done in the way of salvage. It is likely that the decision to use prosthesis will become more conservative and curtailed.

Vitallium cup arthroplasty devised by Doctor Smith-Petersen has been done with varying degrees of success, depending upon many contributing factors. In recent days Doctor Crawford Adams of London, England, has produced a concentrically shaped metal cup which is proving to be successful in arthroplasty. Special instruments are provided to insure accurate fitting of the cup in the joint.

Equalization of leg length has been a problem of this quarter century. Leg lengthening was tried unsuccessfully the world over and was abandoned on account of excessive stretching of blood vessels, nerves and other soft tissues. Arresting growth of the longer leg by preventing further growth of selected epiphyses at calculated age, results in legs of equal length at completion of one's growth at maturity. Doctor Blount of Milwaukee devised the method of temporarily arresting epiphyseal growth by straddling the epiphyseal line with metal staples, which are removed when the desired length of shortening is obtained and legs are of equal length. Then the staples are removed and growth is resumed. This method, of course is applicable only to the growing child. In adults when there is much inequality of leg length a most spectacular and gratifying result is gotten by subtrochanteric femoral shortening.

The lifetime of the Southeastern Surgical Congress has been synchronous with an automobile and industrial revolution, in which there have been more and worse accidents and injuries than in any previous time. It would be impossible to do more than casually relate some of the experiences and accomplishments of ingenious surgeons during this exciting period.

SURGERY FOR MEDIASTINAL LYMPHADENITIS*

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Among the mediastinal lesions which occasionally are operated upon are the so-called tuberculomas, or granulomas. Although only 32 such cases, confirmed by surgical extirpation and pathologic examination have appeared in the literature, recent writers are of the opinion that these lesions are more common than is generally believed. Storey and Lyons[2] and Kunkel, Clagget, and McDonald[1] have reviewed the cases reported and considered the factors favoring surgical removal of these lesions. Since the criteria for operation have not been established with certainty, it is considered that the following 3 case reports are of interest.

CASE REPORTS

Case 1. L. W. S., a 34 old year white man, was admitted to Lawson Veterans Administration Hospital on Oct. 17, 1950. He had been well until about one year prior to admission when he began to cough up small quantities of blood-streaked sputum. Shortly afterwards he noted the onset of dull, aching pain in the left lower chest, radiating through to the back. After a few days, both pain and hemoptysis subsided, but similar episodes occurred at intervals of about two months in the intervening year before admission. Between these episodes, he was asymptomatic.

Admission physical examination was not remarkable. A posteroanterior chest roentgenogram (fig. 1) showed a calcified mass in the right hilum. Lateral tomography (fig. 2) showed the mass lying in the angle between the right middle and lower lobe bronchi. This relationship appeared to be sufficiently intimate to explain the repeated hemoptysis. Many sputum examinations were negative for acidfast bacilli on smear and culture. Two bronchoscopic examinations were made. At the first, gentle probing of the brunchus to the medial basilar segment of the right lower lobe resulted in fresh bleeding. At the second, it was noted that there was some compression of the right lower lobe bronchus just below the middle lobe orifice. Cultures of bronchial washings were negative for acid-fast bacilli and for fungi, and a cell-block from bronchial washings was negative for tumor cells. It was decided that the patient's symptoms were the result of pressure on a bronchus caused by the mass in the right hilum, and operation was advised.

Right thoracotomy exploration was done on February 7. A mass about 3 by 3 cm. in size was found in the right hilum, encroaching upon the substance of the middle lobe of the lung medially and inferiorly. In addition, several smaller nodules could be palpated in the substance of the medial basilar segment of the lower lobe. Dissection of the larger mass showed that it lay in close apposition to both the main lower lobe artery and the middle lobe bronchus. In order to separate the mass, it was necessary to sacrifice a small artery and vein supplying the middle lobe of the lung. The nodules in the medial basilar segment of the lower lobe were removed by excising a wedge-shaped portion of that segment. Streptomycin and P.A.S. (para-aminosalicylate) were given only during the immediate postoperative period, then were discontinued. Recovery from operation was uneventful, and the patient was discharged on Feb. 27, 1951.

The pathologic diagnoses of the resected specimens were "(1) healed tuberculosis, hilar lymph node, and (2) tuberculoma of the lung." Since his discharge, this patient has been

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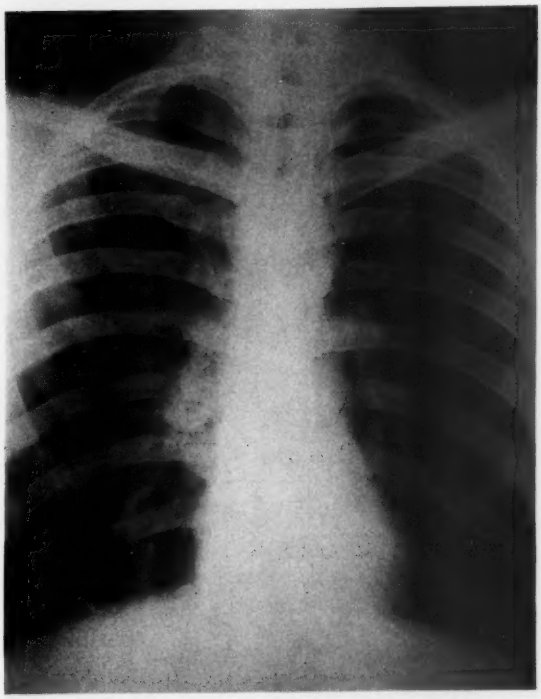

FIG. 1. Posteroanterior roentgenogram showing a calcified mass in hilum of the right lung.

followed at the Veterans Administration Hospital, Jackson, Mississippi. He was seen last on Oct. 14, 1953—more than 18 months after his operation. In the interim, many cultures of sputum have been negative for acid-fast bacilli, and chest roentgenograms at six months intervals have shown no recrudescence of disease.

Case 2. H. A. H., a 30 year old white man, on routine chest roentgenographic examination in the early summer of 1950 was found to have "a spot on his left lung." He was advised to seek hospitalization, and on Dec. 15, 1950 he was admitted to Lawson Veterans Administration Hospital, at which time he denied symptoms related to his chest. Physical examination was negative. Second strength tuberculin test was positive. Complement fixation test for histoplasmosis was negative. A posteroanterior chest roentgenogram (fig. 3) showed a large calcified mass in the left hilar area. Barium swallow and angiocardiography did not show any abnormality. A posteroanterior tomogram (fig. 4) showed that the mass lay in the angle between the upper and lower lobe bronchi. Sputum examinations were negative for acid-fast bacilli on smear and culture. Bronchoscopy was negative except for slight redness and edema throughout the left main stem bronchus. Bronchial washings were negative for acid-fast bacilli, for pathogenic fungi and for tumor cells. It was thought the the mass most likely was tuberculous in origin, and its intimate relationship to main bronchi was considered to be adequate reason for operation.

On Feb. 5, 1951, a left exploratory thoracotomy was done, and a large calcified mass was found in the left hilum. The mass was found intimately attached to two very small arterial branches, which were sacrificed, and to the lower lobe bronchus, from which it

FIG. 2. Lateral tomography showing the scars seen in figure 1 lying in the angle between the right middle and lower lobe bronchi.

was removed without injury. The patient received streptomycin and P.A.S. (para-aminosalicylate) for three weeks. Postoperative recovery was uneventful, and the patient was discharged from the hospital on March 1, 1951. Pathologic diagnosis of the resected mass was "tuberculous lymphadenitis." Portions of the mass subjected to culture and guinea pig inoculation for acid-fast bacilli were negative.

Since his discharge from the hospital, this patient has been followed at intervals; he was last seen on Sept. 22, 1953—more than 30 months after operation. He has remained asymptomatic.

Case 3. A. G., a 38 year old Negro woman, was admitted to Grady Memorial Hospital, Atlanta, Georgia, on July 10, 1950. About eight weeks before admission, she had noted vague, intermittent, substernal "gas-type" pains in her midchest, radiating towards her right axilla. She also noted a nonproductive cough when lying flat on her back, which was relieved by turning to either side. Her past history related that she had injured her chest in an automobile accident 15 years before her present admission, but hospitalization had not been required for treatment.

Physical examination was not remarkable. A posteroanterior chest roentgenogram showed a mass in the right upper mediastinum adjacent to the trachea. A barium swallow showed a slight indentation of the esophagus by the mass which lay anterior to it. An

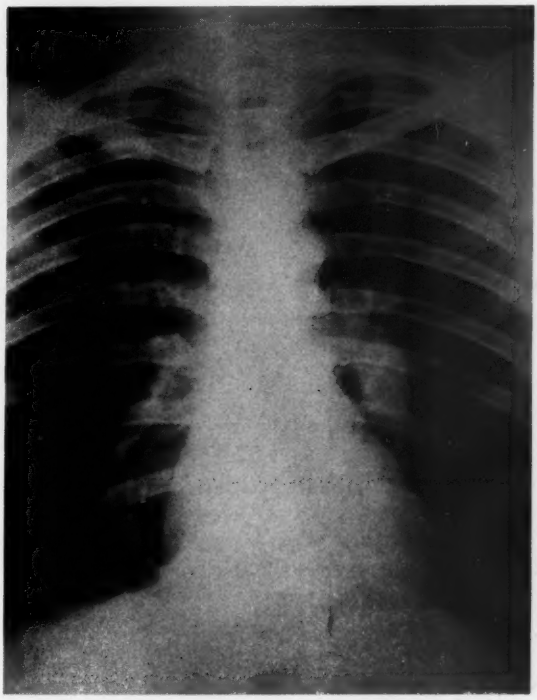

FIG. 3. Posteroanterior roentgenogram showing a calcified mass at hilum of left lung

angiocardiogram showed considerable narrowing of the lumen of the superior vena cava. Venous pressure and circulation times were found to be normal bilaterally. A diagnosis of substernal thyroid was made, and a neck exploration was done on August 28. The mass could be palpated, and was not attached to the thyroid. Since no blood supply to the mass could be determined, it was deemed unwise to attempt to deliver the mass into the neck, and further operation was abandoned at that time. She was discharged from the hospital on Aug. 31.

She was readmitted on September 16, and on September 18, a right exploratory thoracotomy was done. A mass about 4 by 5 by 3 cm in size was found attached anteriorly to the superior vena cava, posteriorly to the trachea, and inferiorly to the right main stem bronchus. Both the phrenic and vagus nerves lay upon the mass. Difficulty was encountered in attempting to separate the mass from the trachea. A small tear was made in this structure which was repaired with interrupted sutures of fine chromic catgut. Rupture of the mass occurred during removal with escape of cheesy material into the pleural cavity. Recovery from the operation was uneventful, and the patient was discharged on Sept. 30, 1950. The pathologic diagnosis was "changes in lymph node (mediastinal) consistent with morphology of tuberculous lymphadenitis." No bacilli were seen in acid-fast stains, and cultures were negative.

In July 1951, almost one year after her thoracotomy, this patient noted swelling and some discharge from one point in her operative scar. Culture of this discharge was positive for acid-fast bacilli. Under local anesthesia in the Out-patient Clinic, the area of swelling was incised, and she received streptomycin for a period of two months. Finally, on Feb. 4,

FIG. 4. Tomogram of mass shown in figure 4

1952, she again was admitted to the hospital, and on Feb. 16, 1952 a wide excision of the sinus tract was done. The wound was packed open and required about a year to heal.

The patient was seen last on April 28, 1954, nearly four years after her surgery. At that time her chest roentgenogram was satisfactory, and there was no recurrence of her chest wall tuberculous sinus.

DISCUSSION

Most of these mediastinal lesions are asymptomatic, and the desirability of prophylactic resection certainly is not known at the present time. Certain features of the condition will lead inevitably to consideration of surgical intervention, and merit further attention.

The difficulties of accurate pre-operative diagnosis in these lesions are apparent. The authors previously cited pointed out that such lesions are typically located in the right hilar area, and 2 of our 3 cases were similarly located. Calcium frequently is visible in routine roentgenograms or tomograms, and while this favors the diagnosis of granuloma, it does not exclude other diseases. Attempts to demonstrate the presence of acid-fast bacilli preoperatively usually are unsuccessful. Tuberculin tests are inconsistent; unfortunately in 2 of our 3 patients this test was not done.

Indeed, it is by no means certain that the tubercle bacillus always is responsible for this lesion, since bacteriologic studies of the resected specimen more often are negative than positive. This is illustrated by our cases, although the subsequent course of the patient in case 3 would seem sufficient evidence of the tuberculous nature of her lesion.

Whether these lesions are tuberculomas or nonspecific granulomas, the possibility of rupture and spread exists. Kunkel and associates stated that several of their cases appeared on the verge of spontaneous rupture and that in three instances progressive enlargement of the lesion on serial roentgenograms occurred. In addition, they cite 2 cases of mediastinal fibrosis presumably originating in such a way, and 1 case of mediastinal cold abscess and fistula thought to originate from a traumatic rupture of a similar lesion. We have had experience with 1 patient who had a huge posterior mediastinal abscess. Over a period of several months, many roentgenologic studies of the spine and lungs showed no source for the infection, and it is believe that the most likely source was the breakdown of a lymph node.

There is a possibility of erosion or compression of a bronchus by such a mass, and this seems borne out by the bronchoscopic findings from the patient in case 1. Case 3 illustrates the possibility of serious vena cava compression.

Because of their intimate relationship to vital structures, removal of these masses frequently requires meticulous and difficult dissection. Whether or not the risk of leaving them undisturbed outweighs that of excision cannot be finally determined on the basis of the small number of cases reported at this time. However, existing evidence appears to favor surgical removal of these lesions.

SUMMARY

Three additional cases of mediastinal, presumably tuberculous, granuloma are reported in some detail.

The difficulties of accurate preoperative diagnosis are noted.

Indications for surgical removal are discussed in terms of the potential complications of mediastinal granulomas.

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IMPALING INJURY OF RECTUM: CASE REPORT*

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Impaling injuries of the rectum are not common, neither are they very rare. The case here reported has features which are a little unusual and which we believe make it worthwhile reporting.

CASE REPORT

R. G. B., a 12 year old white boy, was climbing a tree on the evening of Aug. 17, 1954. His boy friend was giving him a push from behind with a rather sharp stick. The patient lost his grip on the tree and fell backwards, impaling himself on the stick. He thought that the stick went into his rectum for a distance of about 2½ inches. He was seen immediately by his family doctor who sent him to the Accident Room of the Johns Hopkins Hospital, where he was seen by one of us (A. R. K.) at 8:45 p.m. There was a hole in his trousers and also a hole in his shorts where the stick had gone through. There was considerable blood on his shorts.

Physical examination showed an abrasion of the skin to the left of the anus. However, this was not of sufficient importance to account for all the blood seen on the patient's shorts. There was no bleeding from the rectum at the time he was seen. Rectal examination with a sterile glove showed nothing further and there was no blood on the finger of the glove when it was withdrawn. He was apprehensive and complained of pain in the left lower abdominal quadrant, where he also had some tenderness. His temperature was normal. He voided after entering the Accident Room and there was no gross blood in the specimen.

It was thought that the patient might have had a minute perforation in his rectum which accounted for the slight tenderness in the left lower quadrant, but the findings were not very definite. It was decided to admit him to the hospital, and keep him under observation during the night with nothing given by mouth except sips of water. He was given neomycin by mouth and penicillin and streptomycin parenterally.

After he had been admitted to the hospital, the patient's father stated that he thought he had seen him pass some urine from his rectum. Also, after admission, he voided some blood. Because of this, a Foley catheter was inserted.

The next morning, there were more signs of general peritoneal irritation. His temperature was 99.8 F., pulse 120, white blood cells 18,000 per cu. mm. with 85 per cent polymorphonuclears. A cystogram was done by Dr. J. A. C. Colston, who found a distended bladder with possible extravasation, but no communication with the rectum was demonstrated. Proctoscopic examination showed an area on the anterior surface of the rectum, 12 cm. from the anus, which was about 2.5 cm. long and 1.5 cm. wide, and which looked like a contused area. No perforation was seen. The patient vomited several times during the day.

Operation was done (by A. R. K.) at 6:30 p.m. under sodium pentothal and nitrous oxide anesthesia. A midline incision was made from the umbilicus to the symphysis. Immediately upon opening the abdomen, some turbid fluid escaped, which had no odor. Urine and pus were first thought of, but it was soon discovered that the fluid had the characteristics of neither. It then was thought that it must have been some of the sodium iodide which escaped through an opening in the bladder at the time of the cystogram. A perforation was found in the ileum, which was sutured with mattress sutures of fine black silk. The remainder of the small bowel was examined and no other perforations were found. None

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was found in the cecum or sigmoid. There was a perforation to the left of the apex of the bladder and this was sutured with two rows of sutures using no. 00 chromic catgut in the submucous and muscle coats, and mattress sutures of fine black silk in the serous coat. The rectum then was thoroughly examined and no perforation found. It was concluded that the stick must have gone through the rectovesical septum into the bladder and then out through the apex of the bladder, perforating a loop of ileum which was lying close to it. In view of this finding it was decided to do a colostomy in order to divert the fecal flow from the rectovesical fistula. A loop of sigmoid was brought out through a left McBurney incision and a glass rod placed under it. The midline incision then was closed.

Postoperative course. The next day, he was doing very well and the sigmoid loop was opened 24 hours after the operation. He continued to improve during the next few days, his bowels moving both from the colostomy opening and through the rectum. He was given neomycin through the distal loop of the colostomy opening. He also was given penicillin and streptomycin parenterally, and, for the first few days, terramycin intravenously. Proctoscopic examination showed that the lesion on the anterior surface of the rectum looked well and there was no evidence of any communication between the bladder and the rectum. It was thought at the time of operation that, while the stick must have gone through the rectovesical septum, the opening was small and closed itself, so that it was not necessary to do anything except to divert the fecal stream and the urine, as much as possible. Subsequent events proved this judgment to be correct, as he did well and was ready to have his colostomy closed much sooner than is usual in such cases.

The patient continued to improve following the operation of August 18. The urethral catheter was removed on August 30 and he was able to void normally without discomfort. Proctoscopic examination on September 1 showed a granulating area 12 cm. above the anus 2.5 by 1.5 cml in diameter. No urine could be seen coming from the granulating area. The colostomy was functioning well and he was discharged from the hospital on September 2.

The patient did well after returning home. Proctoscopic examination on September 20 showed some irregularity of the rectal mucosa at the site of the wound, consisting of increased redness, but this area did not bleed when touched with a cotton applicator. He was started on Sulfathalidine on September 20, and readmitted to the hospital on September 23. Sulfathalidine preparation was continued with neomycin and after a proctoscopic examination on September 24, the colostomy was closed the same day.

The second operation (closure of colostomy) was done (by R. C. K.) under sodium pentothal and nitrous oxide anesthesia. Incisions were made in the skin parallel to and about 3 mm. away from the colostomy wound on either side. The skin was dissected free from the colon and removed. The colon was freed from the fascia of the external oblique muscle, from the internal oblique muscle, and from the peritoneum. A loop of ileum was rather firmly adherent to the wound and to the colon adjacent to the upper part of the colostomy opening. This was freed with some difficulty causing a considerable tear in the serosa of the ileum. This was repaired with interrupted silk sutures. Another loop of ileum was adherent to the lateral side of the colostomy. This was freed and the colostomy then could be dropped back into the abdomen. The edges of the colostomy opening then were resected with about 1 inch of colon proximal and distal to the colostomy opening. An end to end anastomosis was made with two layers of interrupted silk sutures, joining the proximal and distal stumps. The peritoneum, internal oblique muscle, and fascia of the external oblique muscle were closed in one layer with no. 30 steel wire. The skin was closed with silk. No drains were used.

The postoperative course was entirely uneventful. Sulfathalidine was continued for three days after the operation. A normal stool was passed on the third postoperative day. The wound healed well, and he was discharged on Oct. 1, 1954 on a regular diet. His bowels have moved regularly and without difficulty since the second operation. Proctoscopic examination on Nov. 6, 1954 showed a fine well healed linear scar at the site of the rectal wound. He was last seen on May 21, 1955 and was entirely well.

COMMENT

Review of similar cases reported by other authors reveals that in most patients, drainage of the perirectal space had been established at the first operation. We did not think this necessary in this patient. Other authors have reported that the closure of the colostomy was postponed for three to five months after the original operation, except for the patient of Miller and Long[4] in whom the colostomy was closed in 32 days. Since we could observe the rectal wound through the proctoscope and determine accurately the state of its healing we thought that the colostomy could be closed safely 37 days after the injury. The rather dense adhesions between loops of ileum and the colon near the colostomy site would seem to make early closure of the colostomy desirable in order to minimize kinking and the danger of subsequent obstruction of the small intestine.

SUMMARY

A case is presented of impaling injury of the rectum with penetrating wounds of the rectum, trigone and dome of the bladder, and of the ileum. The wounds of the ileum and the dome of the bladder were sutured and the feces and urine were diverted until healing of the wounds of the rectum and trigone of the bladder was effected. The colostomy was closed comparatively early. Drainage was not used in the perirectal space.

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ACUTE ABDOMINAL PAIN IN POLYCYTHEMIA VERA: REPORT OF A CASE OF SPLENIC INFARCT*

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Polycythemia vera usually is considered a disease of long duration and gradual insidious onset. Medical writers[2] tell us that it affects men more often than women and it occurs most frequently after 40 years of age. It is rare for children and young adults to be affected with the disease. Towle and associates[9] reported a series of 25 cases of patients with an average age of 54 years. It usually is considered a disease of late adult life and occurs in the age period of arteriosclerosis and hypertension. It is thought by some that the disease develops very slowly and requires many years to reach its peak. In many cases symptoms become apparent, but it may be a matter of years before they become so severe that the patient will consult a physician. The patient may become aware of his condition because of his ruddy color, enlarged spleen or a thrombotic or bleeding episode. Severe complications will draw attention to the disease as in the case being reported.

The disease is of particular interest to the general surgeon because of the severe complications which may develop in the abdomen. The incidence of peptic ulcer is higher in these patients. Wilbur and Ochsner[10] investigated 143 cases of proved polycythemia vera at the Mayo Clinic and found that in 12 patients, or 8 per cent, there was roentgenologic or pathologic evidence of peptic ulcer. Towle and associates in a report of 25 cases had 1 patient who developed symptoms of peptic ulcer with massive gastric hemorrhage and a second patient who developed a duodenal ulcer. It was suggested by these authors that peptic ulcer probably is secondary to the thrombosis of vessels in the gastric or duodenal mucosa. Dameshek and Henstell,[3] in reporting 20 cases, found peptic ulcer in 4 patients and suspected an ulcer in another. They thought that congestion in the various abdominal organs produced various types of symptoms referable to the liver, spleen, stomach or intestines.

Tinney and co-authors[7] reviewed 163 cases. In 7 per cent of these patients a roentgenologic diagnosis of peptic ulcer was made. One patient was operated upon, at which time a carcinomatous gastric ulcer was found. The same writers[8] reported that symptoms referable to the spleen frequently are the chief complaints and may be the only complaints of the patient. They found the spleen easily palpable in 66 per cent of their series. Splenectomy for symptomatic relief was considered, but was not done in 2 patients in whom the spleen was large and painful. It should be kept in mind that the patient with polycythemia vera also may have an enlarged spleen caused by another disease. Guild and Robson[5]

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reported the case of a 62 year old woman with polycythemia vera and tuberculosis. She was treated with streptomycin with dramatic response, but the spleen did not reduce in size. A splenectomy was done and the pathologic examination showed a tuberculous splenomegaly. Burris and Arrowsmith,[1] in reviewing 68 cases of polycythemia vera, reported the cases of 2 patients, ages 22 and 39 years, with hepatic vein thrombosis. The younger patient died of hepatic insufficiency 13 months after the onset of symptoms. The second recovered after venesection, administration of radioactive phosphorus, and prolonged therapy with dicumerol. Falconer[4] reported 2 cases of patients who had attacks of pain in the right upper quadrant of the abdomen which they thought were caused by gallbladder disease. Surgery was considered for 1 of the patients, even with normal roentgenographic findings, but medical treatment for the polycythemia vera apparently cleared up the attacks of pain. According to his experience the patients with large spleens do not respond well to any type of treatment.

Thromboses, either arterial or venous, may occur as complications of polycythemia vera and may affect the peripheral, mesenteric or cerebral vessels. When a mesenteric thrombosis occurs abdominal pain may suggest an acute abdominal condition requiring surgical intervention. Lawrence and co-authors[6] believed that with the use of P-32 (intravenous radioactive phosphorus) in the treatment of polycythemia vera the danger of hemorrhage or thrombosis is minimized. Prior to the introduction of this therapy, approximately 50 per cent of the patients died either of thrombosis or hemorrhage. In reporting a study of 263 cases of patients with this disease these authors found 1 patient who had a portal thrombosis.

The following case is being presented mainly because of the early age and sex of the patient and because of the acute sudden onset of symptoms which later led to the diagnosis of polycythemia vera. It is believed that the patient probably had the disease for a considerable length of time, but only the sudden abdominal catastrophe brought her into the hospital for medical care.

CASE REPORT

Mrs. O. M., age 22 years, was admitted to the Wichita-St. Joseph Hospital on March 27, 1953 complaining of pain in the upper abdomen. This pain had started suddenly three days previously and was sharp and intermittent in character. The pain increased and became more constant, so she sought medical aid. The patient's past history revealed nothing unusual. She had been working every day and had only been in the hospital previously for the delivery of two babies. She had had no serious illnesses or operations. There was no history of weight loss. The patient's mother had died of carcinoma of the uterus at the age of 45 years and the family history was not remarkable otherwise. When the patient first was admitted she was in considerable pain. The examination at that time showed a tender mass in the left upper abdomen and there was mild muscle guard and rigidity in that area. The patient's color was not unusual.

She had been vomiting and still was nauseated on admission. Her general condition had deteriorated considerably in a short time prior to examination. The examination was normal except for a rather weak rapid pulse and the abdominal findings. The abdomen was very tender and there was definite rigidity in the left upper quadrant. The spleen could not be felt because of the rigidity. There was considerable rebound tenderness present. On admission the blood count was as follows: red blood cells 7,990,000 per cu. mm.

with 17 grams of hemoglobin. The white blood cells were 14,500 per cu. mm. and the differential count showed an increase in the polymorphonuclear cells. The urine was normal. The next day after admission the red blood cells were: 6,060,000 per cu. mm. with 15 grams of hemoglobin and the white blood cells had risen to 25,650 per cu. mm. On March 29, two days after admission the following count was obtained: red blood cells 7,400,000 per cu. mm. with 16.5 grams of hemoglobin; white blood cells 30,000 per cu. mm. The platelet count was 170,000 per cu. mm. The bleeding time was 1 minute and the coagulation time was 4 minutes, 28 seconds.

It was thought that the blood count could be due to hemoconcentration because of her lack of fluids and vomiting. A clinical diagnosis of spontaneous rupture of the spleen was made and she was operated upon as an emergency.

A left upper rectus incision was made. A very large spleen was found which measured approximately 25 cm. long, 15 cm. wide and 10 cm. thick. The omentum was adherent to the anterior and lower surfaces of the spleen. The spleen had a mottled appearance and the inferior one-third was dark blue in color. A splenectomy was done with considerable difficulty. The patient's condition was not good during the operation. She received 500 cc. of whole blood during the operation and was returned to her room in fair condition.

Following operation, the next day, the blood count was as follows: red blood cells 5,930,000 per cu. mm. with 14.5 grams of hemoglobin. The pathologist reported an infarct of the spleen with splenomegaly (fig. 1).

Her convalescence after operation was not smooth, but she gradually improved. The red blood cell count remained high. On April 10, a sternal bone marrow biopsy was done. This was reported by the pathologist as being consistent with polycythemia vera. She was dismissed from the hospital in good condition on April 15.

FIG. 1. Splenomegaly showing large infarct

On May 5, she was given 5.75 mc. of P-32 intravenously. At that time the red blood cell count was 5,210,000 per cu. mm. with 15.9 grams of hemoglobin. The white blood cell count was 12,000 per cu. mm. with a normal differential count. She failed to report for observation until Sept. 15, 1953. At that time she had gained 15 pounds and again was working every day. The red blood cell count then was 3,280,000 per cu. mm. with 10 grams of hemoglobin. She did not come in again until Feb. 4, 1954 at which time she complained of tiring easily. Her last menstrual period occurred three months previously and upon examination the uterus was found to be approximately the size of a three months pregnancy. At that time the red blood cell count was 4,220,000 per cu. mm. with 11.6 grams of hemoglobin and white blood cell count of 14,950 per cu. mm. The platelet count was then 360,000.

Nothing was heard from this patient until May 7, 1954. At that time she was approximately seven months pregnant. Intestinal obstruction was considered because of abdominal distention. She had been admitted to Wesley Hospital on the above date with a blood count as follows: red blood cells 1,280,000 per cu. mm., hemoglobin 26 per cent and 18,400 white blood cells per cu. mm. The platelets count was 560,000. She was vomiting and was passing some bright red blood in her stools which were liquid. It was decided that she did not have intestinal obstruction. Apparently she had some gastrointestinal bleeding. She was not in shock.

She later vomited considerable blood and was treated with whole blood transfusions. Her general condition improved and it was considered advisable, in view of her bleeding tendency, to deliver her by cesarean section and at the same time do a hysterectomy to prevent postpartum bleeding. This was done on May 21, 1954 and at the same time an exploration of the upper abdomen was done. The small intestines were matted together in the splenic bed and the transverse colon was adherent under the old splenectomy scar. There was no evidence of any splenic implants. Numerous adhesions were divided. A normal male child was delivered.

She survived the operation very well and her convalescence was satisfactory. The child did very well. She was dismissed from the hospital June 4, 1954. During her hospital stay she received 18 whole blood transfusions of 500 cc. each. On dismissal from the hospital her blood count was as follows: red blood cells 4,630,000 per cu. mm., hemoglobin 97 per cent and white blood cells 10,000 per cu. mm. A platelet count was not made at that time. She has continued to do well and has had no bleeding episodes to March 15, 1955.

DISCUSSION

The above case is of particular interest to the surgeon because of the sudden acute abdominal symptoms secondary to an infarct of the spleen. The treatment was splenectomy. The age and sex of the patient is of considerable interest since the disease occurs most frequently in males of a more advanced age.

Several months following her splenectomy the patient became pregnant and was delivered by cesarean section and at the same time a supracervical hysterectomy was done. Numerous loops of small bowel were adherent in the splenic bed but no splenic implants were found.

SUMMARY

A general discussion of polycythemia vera and its related abdominal conditions is presented.

A case of polycythemia vera in a 22 year old white woman with splenomegaly and a large infarcted spleen is presented.

Treatment consisted of emergency splenectomy, later followed by the intravenous injection of P-32.

The patient later was admitted to the hospital approximately seven months pregnant, with intestinal distention and gastrointestinal bleeding. She was delivered by cesarean section and at the same time a supracervical hysterectomy was done. Her convalescence was satisfactory.

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DIAGNOSIS AND MANAGEMENT OF PEPTIC ULCER SHOWING TWENTY-FIVE YEARS OF PROGRESS*

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I have been asked to talk on the diagnosis and treatment of peptic ulcers and to review the changes that have taken place during the past 25 years. This subject was discussed at the first clinical session of this society by my father, the late J. Shelton Horsley[3]. Now, as then, the treatment of peptic ulcers of the duodenum is and should be different from the treatment of peptic ulcers of the stomach. While their etiology may be the same, their treatment and prognosis both from the medical and surgical points of view are different. The theories as to the etiology of peptic ulcers have changed little and the methods of diagnosis essentially are the same. No single factor satisfactorily explains the etiology of peptic ulcers. One requirement for the development of these ulcers is hydrochloric acid and pepsin which brings about the proteolysis of injured or devitalized tissue. Other factors which promote ulcer formation are abnormalities of the blood supply, infection, allergy and injury to the duodenal or gastric wall. There still are other extragastric factors which may be important in ulcer formation such as lesions of the midbrain, vagal stimulation and hormones which motivate gastric activity and hypersecretion.

It was in the nineteen hundred and twenties that the influence of vagal stimuli on the production of peptic ulcer first was forcefully emphasized. Hughson[4] and Cushing[1] both thought that nervous stimuli from the midbrain brought down by the vagus had much to do with the development of the ulcers and once an ulcer was formed it was found that these stimuli prevented their healing.

Duodenal ulcers are much more frequent than gastric ulcers. There has been no change in this ratio during the past 25 years. In 1930 a report from the surgical service of the Mayo Clinic showed 524 cases of duodenal ulcers as compared with 85 gastric ulcers and 251 cancers of the stomach. Their report for 1953[5] showed 405 duodenal ulcers which required some type of operative procedure and 186 gastric ulcers which were operated upon. This same report noted 223 cases of gastric malignancies. Comparing these two reports it is obvious that the number of duodenal ulcers and gastric cancers have remained about the same, there being a few less reported in 1953 as compared to 1930. However, the big change has been in the number of gastric ulcers removed, there being only 85 in 1930 and 186 in 1953. This shows an awareness of the dangers of gastric ulcers and the importance of their removal.

The frequency of peptic ulcers has changed little in the last 25 years. There always is an increase in the number of cases during times of stress as shown during the war periods and also in periods of marked financial fluctuations.

From the Surgical Department of St. Elizabeth's Hospital, Richmond, Va.

* Presented during the Atlanta Assembly of the Southeastern Surgical Congress in Atlanta, February 21–24, 1955.

Peptic ulcers still are more frequently found in the male than in the female and this tendency is more marked in gastric ulcers than in duodenal ulcers. Men will have approximately twice as many benign gastric ulcers as will women and four times as many malignant ulcers as are found in women.

Another encouraging observation in this report from the Mayo Clinic is the increase in the resectability of the gastric cancers from 37 per cent in 1916 to 65 per cent in 1953. This is due, unquestionably, to a high index of suspicion of all gastric ulcers. Such a laudable change in percentage of resectable cancers of the stomach can be noted throughout the entire country today.

DISCUSSION

The methods of diagnosis of these conditions have changed very little. To be sure, we have added some refinements to our approach but the fundamentals are the same, namely, careful history, physical examination, laboratory studies and roentgenologic studies which then and now includes both fluoroscopic and film examinations of stomach and duodenum after the ingestion of a barium meal. To these we have always advocated a gastric analysis. In spite of its often seemingly inconsistency as to the presence or absence of free acid and the amount or degree of both free and combined acid, this is a test that should never be left out and is most helpful in the treatment whether it be medical or surgical.

To these studies have been added the gastroscopic examinations. These are of very little value in the diagnosis of peptic ulcers of the duodenum, but are a distinct adjunct in the correct diagnosis of difficult gastric cases and will help determine whether malignancy is present and whether any healing is taking place in the ulcer edges.

Cystologic studies of gastric washings and the use of a roughened balloon to bring out gastric cells have proved helpful in determining the presence or absence of a gastric neoplasm, but are of no value in the diagnosis of duodenal lesions. Even in the hands of the most skilled operators, there are certain blind areas in the stomach which cannot be seen by gastroscopy and unfortunately these are the same areas which give the roentgenologist the most trouble. Both of these latter methods often fail when they are most sorely needed, which is true with many of our newer procedures.

TREATMENT

The theory and practice of treating peptic ulcers has changed little in the past 25 years. There are certain refinements that have been added to both the medical and surgical procedures but the fundamentals of treatment are the same.

Duodenal ulcers may and should be treated medically unless they develop complications. The complications that require surgery are the same now as they were in 1930, namely, severe hemorrhage, perforation, obstruction and intractable pain. Unless one of these conditions develops, medical treatment of a duodenal ulcer can and should be continued indefinitely. To operate upon a duodenal ulcer because the patient does not wish to or cannot be made to stick to his medication, diet, and ulcer regime is foolhardy. This is true for both the surgeon

and the patient, for if the patient will not carry out his treatment before operation he will, in all probability, do no better after operation, and a recurrence of his symptoms and ulcer is very likely to occur. It is thought so often by the patient that if a duodenal ulcer is present and it is removed, or as they call it *cut out*, then he can go *on his way rejoicing* with never a worry concerning his gastrointestinal tract, and that he can again insult it with all kinds of food and drink. This we know is far from the truth and, while treating an ulcer patient either medically or surgically, it is most important to impress upon him that *once an ulcer patient, always an ulcer patient*, and in order to get well and stay well, he must permanently change his eating and living habits.

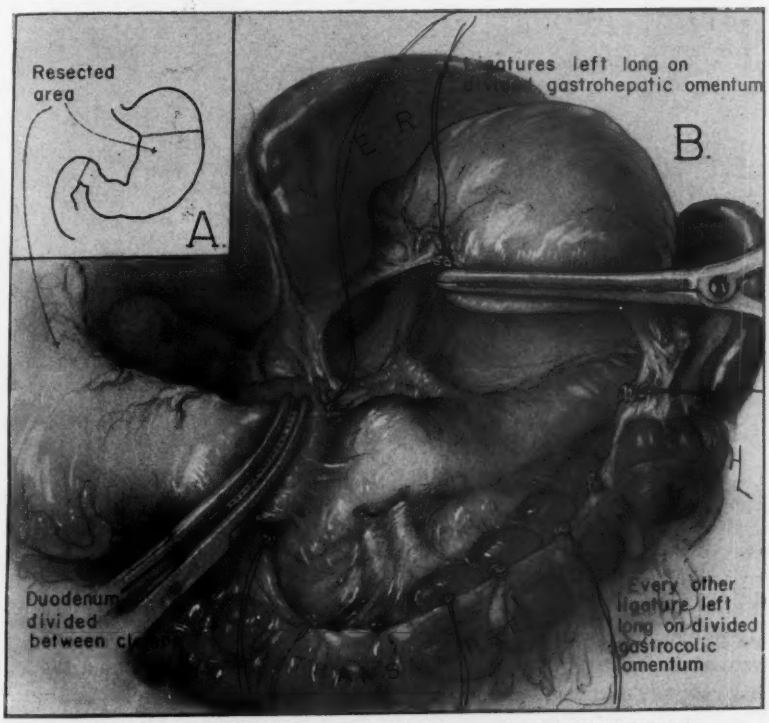
If a duodenal ulcer requires surgery, the treatment has not been changed radically from that of 25 years ago. Partial or subtotal resection was then just coming into prominence. The procedures practiced a decade or so before that time, namely, gastroenterostomy and pyloroplasty, fast were falling into disrepute because beginning to show up were their late complications, namely recurrence of the ulcer and/or a marginal gastrojejunal ulcer. These later complications were found to be a more severe condition and more troublesome than the original ulcer.

The surgical treatment of a perforated ulcer a quarter of a century ago was simple closure of the perforation with an occasional gastroenterostomy if obstruction or impending obstruction was present. The nonsurgical treatment of perforation was not considered then and, in my opinion, should not be considered now. Gastric resection, as advocated by Emmett and associates[2] and later by others, had not been seriously considered. But now with the availability of antibiotics, better anesthesia, and a keener understanding of electrocytes, gastric resection in certain cases of perforation of duodenal or gastric ulcers is the operation of choice.

In the surgical treatment of peptic ulcers, especially of the duodenum, vagotomy has come into prominence in the past 25 years having been much more fashionable a few years ago than now. Like so many fads and fashions, it loomed into prominence and vagotomy alone was considered by some the only treatment necessary. I well remember a feature article in the Sunday supplement of a newspaper stating unequivocally that all an ulcer patient had to do was to have a nerve cut and his condition would be cured permanently. Vagotomy has now fallen into its proper place in the armamentarium of the abdominal surgeon, and is a valuable adjunct to resection or gastroenterostomy but is of little value alone. But vagotomy is not really a new procedure. As early as 1927, my father was doing it along with a pyloroplasty or a gastroenterostomy. The vagotomy he did then was not as complete as the one practiced now, but it succeeded in reducing the motility and acidity of the stomach. This I know, for it was very forceably brought to our attention as house officers that all patients who had had their gastric vagus cut had a much longer period of gastric retention which required gastric lavages twice a day for as long as 10 days or more. This was not true, however, in patients with similar operations when the vagus was left intact. We believed also that there were fewer recurrent ulcers when the vagus

had been divided. As stated above the vagotomy of that era was not as complete as that practiced now, for the anterior or left gastric nerve was the only one cut and the division was made below the diaphragm at the esophagogastric junction.

When and if a gastric resection is done, we still prefer a Billroth 1 type operation and in our hands believe we can resect just as much of the stomach as with the Billroth 2 type operation. When the resection seems indicated, we remove the ulcer whenever possible. After the resection has been completed, it is decided then what type of anastomosis should be done. We never do the resection with an eye on the preferred type of anastomosis. Before any closure of the duodenum is considered, the duodenum first is mobilized and it is amazing the number of gastroduodenal anastomoses that can be done without difficulty or tension. This type of operation has been advocated by my father since 1925. We have changed the technic of this operation very little since its original descrip-



FIGS. A–J. Partial Gastrectomy—Horsley modification of Billroth I

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FIG. A. Amount of stomach to be removed is shown by dotted lines

FIG. B. The stomach has been doubly clamped, divided between the Payr clamps, and lifted upward and to the right. Line of division of duodenum is shown.

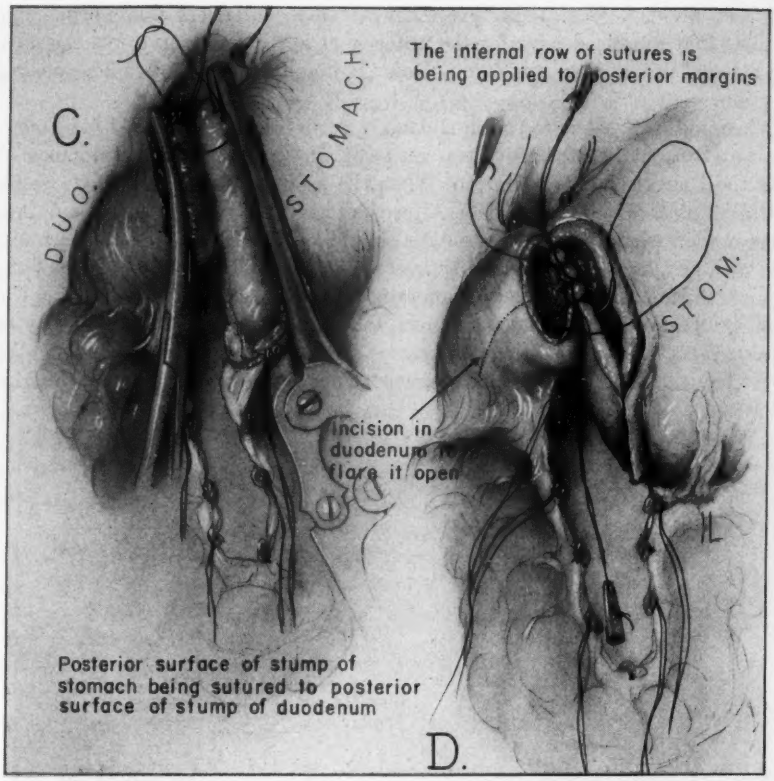
C.
DUO.
STOMACH.
The internal row of sutures is being applied to posterior margins
STOM.
Incision in duodenum to flare it open
IL
Posterior surface of stump of stomach being sutured to posterior surface of stump of duodenum
D.

FIG. C. The resected portion has been removed and the duodenum and stump of the stomach have been approximated.

FIG. D. The two clamps have been removed and the inner row of sutures in the mucosa has been started. The line of incision in the duodenum is shown.

tion. We now do a gastrostomy and transgastric duodenostomy which are used respectively for gastric drainage and early tube feeding. This addition we think has been a step forward as it promotes early rehabilitation of these patients. Their weight loss during the postoperative period is practically nil.

It is most pleasing to note that many of our severest critics in years past now are beginning to advocate the Billroth 1 operation and write about it as though it were a new discovery. Of course there are certain patients in whom the Billroth 1 cannot be carried out and some type of Billroth 2 is done.

The management of gastric ulcers is an entirely different story from duodenal ulcers, but is the same as advocated 25 years ago, namely, if a gastric ulcer does not heal in several weeks, not months, under adequate medical treatment, and if roentgenologic studies do not show the ulcer completely healed, not just improved, then operation is indicated.

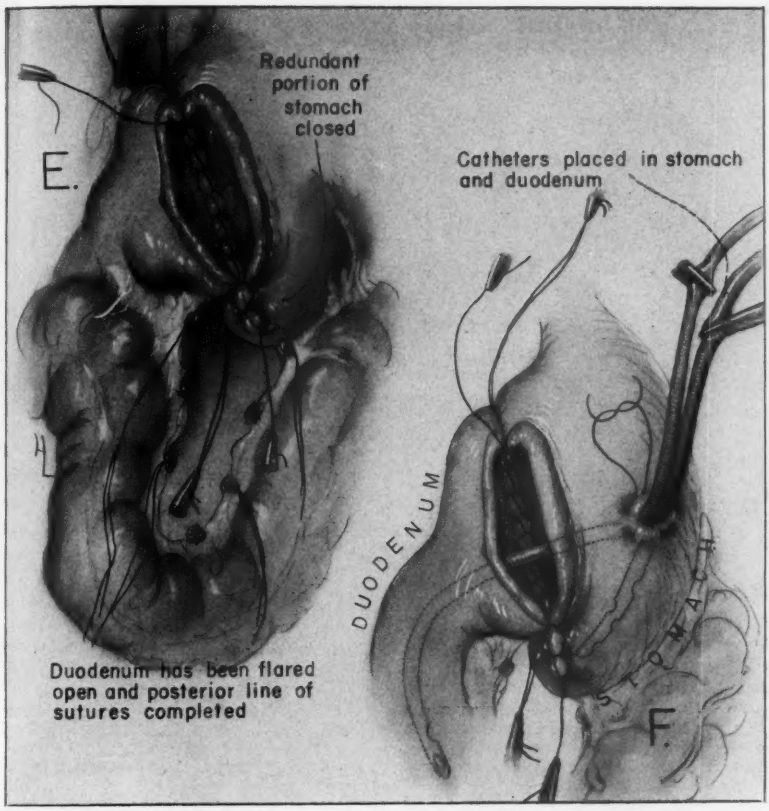

FIG. E. The posterior row of sutures has been completed and the duodenum has been flared open.

FIG. F. The gastrostomy and enterostomy tubes are shown in place and sutured to the gastric wall.

A case report taken from the original article by Dr. Horsley, Sr., is as follows:

"A man, aged 34, complained of marked stomach trouble for nine months, with a history of some symptoms, particularly hunger pains for a period of eight years. For the preceding nine months, however, the pain had been more definite, and he would vomit undigested food. The symptoms were less severe on an ulcer diet, but gradually increased and he recently vomited some blood. The pain became more constant with less relation to meals. A roentgenologic diagnosis of pyloric ulcer having been made elsewhere, he was admitted to St. Elizabeth's Hospital on Feb. 2, 1928. There was no history of cancer in his family.

About 45 minutes before the time set for the operation, symptoms of perforation developed. At operation there was in the pyloric region a small cracklike perforation which evidently had just occurred. A partial gastrectomy according to the modified Billroth 1 technic was done.

The patient recovered satisfactorily. The specimen consisted of the pyloric end of the stomach which measured 12 cm. along the greater curvature and 7 cm. on the lesser curva-

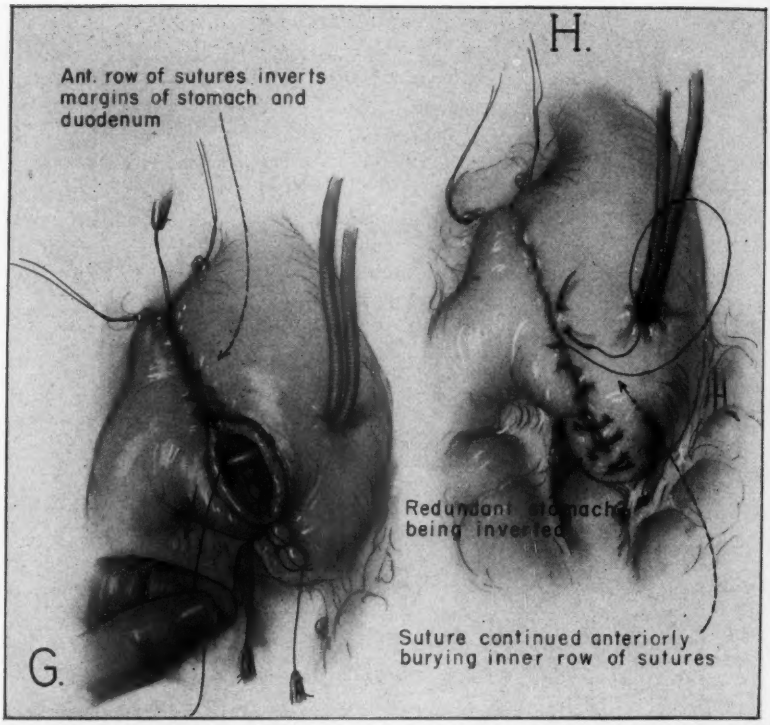
H.
Ant. row of sutures inverts margins of stomach and duodenum
Redundant stomach being inverted
Suture continued anteriorly burying inner row of sutures
G.

FIG. G. The first row of anterior sutures is being placed. The suture is tightened as it emerges from the gastric mucosa.

FIG. H. The small pouch of stomach is inverted and the second row of anterior sutures is being placed.

ture. In the anterior wall there was an excavating ulcer, much of which had a very thin wall. At one point there was a perforation. Sections from the base of the ulcer showed what appeared to be inflammatory tissue. Sections from an adjacent lymph node showed no metastasis but only hyperplasia.

For more than two years he did very well. Then he began having more stomach trouble and returned on Sept. 29, 1930 with secondary anemia, a history of gas and fullness in the stomach, general fatigue, and diabetes which had been treated by his physician for the past five months. Beneath the operative scar there was a palpable mass which felt like cancer. The specimen previously removed was examined again, and another block taken from the margin of the ulcer showed definite carcinoma of moderate malignancy. Roentgenologic examination revealed considerable constriction of the outlet but apparently no filling defect. The carcinoma seemed to infiltrate beneath the mucosa, and apparently another operation would not benefit him. The fact that blocks from the crater of the ulcer showed what seemed to be inflammatory tissue and from the margin definite cancer, especially when taken in connection with the history of the case, indicates that this cancer resulted from a peptic ulcer."

Just recently I have had another case which illustrates the danger and fallacy of continuing treatment on a supposedly benign gastric ulcer. A man 46 years

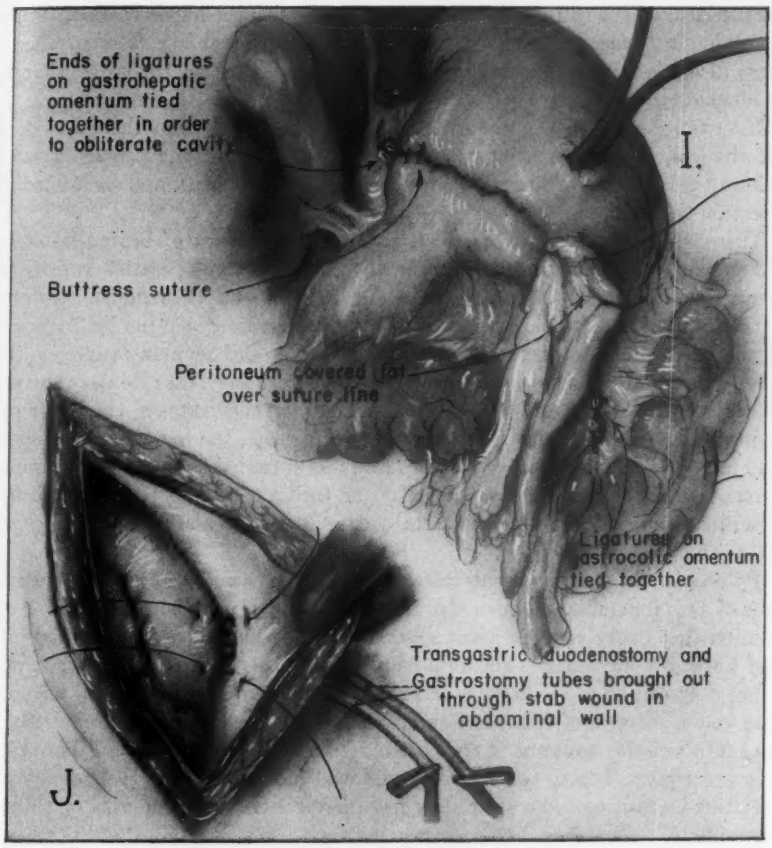
Ends of ligatures on gastrohepatic omentum tied together in order to obliterate cavity
I.
Buttress suture
Peritoneum covered fat over suture line
Ligatures on gastrocolic omentum tied together
Transgastric duodenostomy and Gastrostomy tubes brought out through stab wound in abdominal wall
J.

FIG. I
FIG. J

of age complained of indigestion. Routine roentgenologic studies showed a small but distinct gastric ulcer in the pyloric area. He was followed by his internist from March 1954 to January 1955 with an adequate medical diet and therapy. Repeated reontgenograms were taken and reported improvement of the ulcer which was thought to be benign, but the ulcer crater always was present. In January of this year, 10 months after the original diagnosis, roentgenologic studies showed the ulcer to be present and increased in size. At operation he had an extensive carcinoma with multiple metastases to the omentum and gastrohepatic ligaments. Had this patient been operated upon in April when his second roentgenogram showed the ulcer improved but still present, he surely would have had a much better chance of cure.

In benign ulcers of the stomach, gastric resection is the treatment of choice if they do not heal promptly. The possibility of malignancy then is excluded for

the present and the future, and this operation, done in the hands of those trained for abdominal surgery, entails very little risk. The possibility of recurrence of these ulcers is very small and the prognosis is much more favorable than for duodenal ulcers.

If a gastric ulcer heals and stays healed, well and good, but if it breaks down the chances of its either being malignant or becoming malignant is too great to risk any delay with further supportive or medical treatment, and an immediate resection is indicated.

There is no place for total gastrectomy in the treatment of benign lesions of the stomach or duodenum but occasionally this extensive operation is done because there are indications that the lesion is malignant. If malignancy is present, a total gastrectomy is not indicated if the malignancy is in the pyloric region of the stomach. It has been shown in many clinics and by many surgeons that total gastrectomies have not improved the five year survival rate over the partial or subtotal resections. The morbidity and mortality rates in the latter procedures is much less and even if there is a recurrence, the remaining postoperative life of the patient is more pleasant and useful than when the entire stomach is removed. In certain cases of cancer of the cardia or fundus of the stomach or in linitis plastica types of cancer, total gastrectomy necessarily is the procedure of choice.

Pyloroplasties and gastroenterostomies still have a place in the armamentarium of the abdominal surgeon. In later years and up to the present, it is my opinion that every surgeon doing gastrointestinal work should be familiar with and know the advantages and disadvantages of these procedures so when indicated they can be used. There is too much dogmatism now in surgical teaching. The young surgeon of today is taught one technic or method and frequently he goes into practice ignorant of the advantages and disadvantages of other operative procedures. I have talked with some who have completed their training in excellent institutions who state they have never seen a pyloroplasty or Billroth 1 resection.

The tragedy of a gastric ulcer treated too long as benign and later found to be in the late stages of malignancy makes an indelible impression upon all concerned, both the surgeon and the internist. Fortunately this happens infrequently but it is frequent enough to keep all of us aware of this disastrous possibility.

"The following facts concerning cancer of the stomach cannot be too strongly emphasized: every year there are in the United States about 35,000 deaths from cancer of the stomach; about one-fourth of the cancers of the stomach seem to arise from some benign lesion that has given symptoms for months or years before the cancer developed; in 23 per cent of necropsies of gastric cancers the cancer was still confined to the stomach at the time of death; more than 14 per cent of necropsies show death from perforation. Although at death in 23 per cent of cancers of the stomach, the disease still is confined to the stomach, only 7.7 per cent of gastric cancers are operated on by excision which is the only known cure for gastric cancer. Early diagnosis and radical operation afford the only means of lessening the ravages of this disease."

CONCLUSION

This last paragraph is a direct quotation from the address made before your society at its first clinical meeting here in Atlanta by the late J. Shelton Horsley. These facts are just as true now as they were then, although, unfortunately, the actual total numbers have increased during these intervening years.

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SURGICAL TECHNIC

FEMORAL VEIN THROMBECTOMY AND REGIONAL HEPARINIZATION IN LIEU OF VENA CAVA LIGATION FOR THROMBOPHLEBITIS AND PULMONARY EMBOLISM

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At present, the treatment of uncomplicated deep vein thrombosis, whether a bland process (phlebothrombosis) in the calf or a femoroiliac thrombophlebitis in the groin, consists essentially of anticoagulant therapy. Contrarily only a bare minority believes that anticoagulant therapy alone is adequate for venous thrombosis complicated by pulmonary embolism. Surgery and anticoagulant therapy together afford greater protection than either therapy alone. It is the belief of this author that the first embolic attack calls for surgical intervention. This paper is concerned with the surgical procedures available for this condition and with the description of a modification which has been successful in 15 successive patients.

The surgical procedure most commonly used for femoroiliac thrombophlebitis and pulmonary embolism has been a superficial femoral vein thrombectomy and ligation on the clinically involved side and a prophylactic superficial femoral vein ligation on the opposite side. Enthusiasm for surgical intervention through the area of thrombophlebitis lessened as reports of postligation embolism were published. Veal and associates[16] reported 9 cases, Loewe and co-workers[5] 5 cases, 1 of which was fatal, Thebault and Ward[15] referred to several personal cases, and Allen and Donaldson[1] stated that of 464 patients who had had superficial femoral vein ligation, 5 per cent had infarcts after the procedure. Moses[11] stated that 2 of the 35 patients upon whom he did vena cava ligations had had embolism after a bilateral superficial femoral vein ligation. Prior to using the presently described method, the author had observed several sublethal attacks of postligation embolism in patients in his private practice, the clot presumably arising from the vein stump proximal to the upper ligature or from the femoral profunda.[6, 7]

Between 1945 and 1950 inferior vena cava ligation became popular for deep vein thrombosis which was complicated by pulmonary embolism. The advantages claimed for vein ligation above the upper limits of the thrombophlebitic process were:

(1) Complete absence of thrombosis proximal to the ligature.

(2) No instances of recurrence of embolism.

(3) Elimination of the danger inherent in the thrombectomy procedure of overlooking a small clot or leaving a rough thrombus attached to the vein wall.

Read during the second annual meeting of the Virginia Surgical Society at Williamsburg, Jan. 22, 1955.

(4) Prevention of further embolization from the two great sources of pulmonary emboli, the lower extremities and the pelvis, by one surgical procedure.

The dictum of the proponents of inferior vena cava ligation was immediate vena cava ligation for deep vein thrombosis extending above the inguinal ligament (i.e., femoroiliac thrombophlebitis) complicated by pulmonary embolism. Some enthusiasts even called for vena cava ligation for phlebothrombosis in the calf veins complicated by pulmonary embolism. Assuredly, ligation of the superficial vein just distal to the femoral profunda fulfills all the surgical requirements for such a situation.

I have in my files the report of 225 caval ligations. They are Madden[8] 18, Shea and Robertson[14] 25, Collins and Associates[3] 70, Veal and Hussey 30, Owens[12] 11, Moses 35, and Thebault and Ward 36. During the same period of time I have done vena cava ligation only once. The patient, operated upon elsewhere, continued to have embolic attacks after a superficial femoral vein thrombectomy (no regional heparinization). He made an uneventful recovery following the caval ligation.

As is to be expected, there is considerable variation in the indications listed for vena cava ligation by the numerous authors. Typical of the indications given by the proponents of caval ligation are those listed by Payne.[13]

(1) Proved pulmonary embolus associated with:
   a. Unilateral iliofemoral phlebitis.
   b. Bilateral common femoral phlebitis.
(2) Proved pulmonary embolus without obvious source of emboli.
(3) Ascending venous thrombosis with a contraindication for anticoagulant therapy.
(4) Pelvic thrombophlebitis with septic pulmonary emboli, as in
   a. Pelvic peritonitis.
   b. Infected abortion with parametritis.
(5) Ascending venous thrombosis, without pulmonary emboli, but uncontrollable by anticoagulant therapy.
(6) Blue phlebitis or phlegmasia cerulia dolens.

In this list this author would limit caval ligation to indications four and five—pelvic thrombophlebitis with septic emboli and blue phlebitis. A further indication would be recurrence of embolism after superficial femoral thrombectomy and regional heparinization. I cannot subscribe to caval ligation for pulmonary embolism of which the source remains obscure. Fowler and Bollinger[4] have shown that 52.8 per cent of pulmonary emboli come from the right heart.

Many of the earlier proponents of vena cava ligation have lessened their enthusiasm for the procedure or narrowed their indications. In the first place, an operation of considerable magnitude requiring spinal anesthesia or general anesthesia in a seriously ill patient, carried with it a small but definite mortality rate. Thus 13 of Moses' 35 patients died, 4 of Thebault and Ward's 36 patients failed to survive, 3 of Veal's 30 patients and 8 of Collins' 70 patients died. Second, the postcaval ligation morbidity rate has been considerable although variable and unpredictable. It seems to have been considerably greater in men than in

women. Veal has observed serious arterial spasm of the normal leg, thrombosis of the deep veins of the uninvolved or normal leg, massive bilateral leg edema for several months, and extensive collateral venous anastomoses in the lower abdomen in men. Practically all of his patients developed a bilateral postthrombophlebitic syndrome and had to support their legs with strong elastic stockings to control the tendency to swelling. Ortner, referring to marked postligation dyspnea on exertion in his patients, explained that the phenomenon was due to incomplete filling of the right heart. Madden noted that the postligation edema always was greater on the uninvolved side and explained this phenomenon as due to lack of stimulation to collateral circulation prior to operation by the thrombophlebitic process. Shea and Robertson reported the following postligation sequelae in their group of 25 patients: 20 had legs tiring easily; 20 exhibited pitting edema; 16 developed varicosities; 16 exhibited induration of the legs; 14 showed calf tenderness; 13 had an increase in leg diameter; 12 never were without swelling of the legs postoperatively; and 10 had leg ulcers which tended to heal with rest, only to recur with activity. Only 16 of the patients in their group had resumed full normal activity in the four year follow-up period.

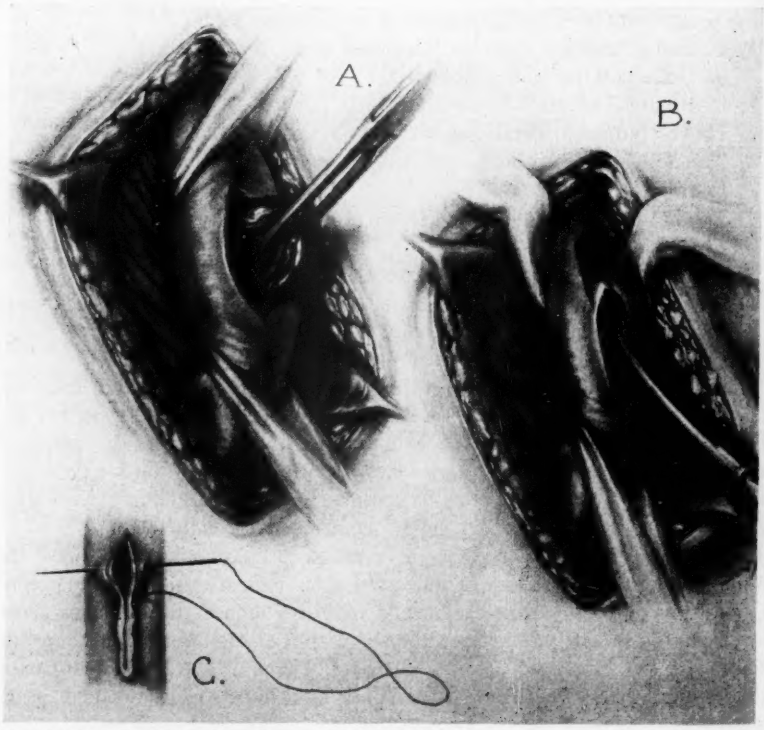

FIG. 1 (A & B). Vein thrombectomy. (Reprinted by permission of Howard Mahorner, M.D., author of "A New Management of Thrombosis of Deep Veins of the Extremities," which appeared in The American Surgeon, May 1954.)

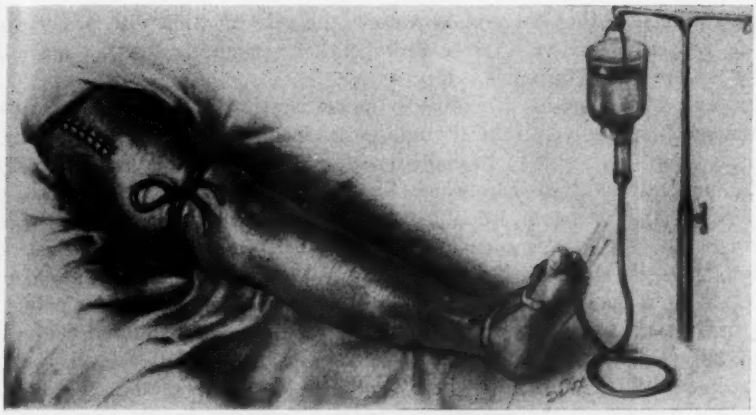

FIG. 2. Postoperative regional heparinization. (Reprinted by permission of Howard Mahorner, M.D., author of "A New Management of Thrombosis of Deep Veins of the Extremities," which appeared in The American Surgeon, May 1954.)

It is clear that in the fully developed femoroiliac thrombophlebitis and pulmonary embolism there is little unanimity of opinion as to therapy. Classic superficial femoral vein thrombectomy supplemented by systemic heparinization has not been uniformly adequate, postligation embolism having occurred. Inferior vena cava ligation subjects a seriously ill patient to a major surgical procedure and has been accompanied by some mortality and great morbidity.

Recently a new method of treating deep vein thrombosis has been described by Mahorner[9, 10] (figs. 1, 2). Mahorner's aim is to open the involved vein and to keep it open. His procedure consists of a thrombectomy followed by restoration of the vein lumen and indirect regional heparinization. The thrombosed vein, usually the superficial femoral, is incised longitudinally and the clot is removed by forceps, suction or by pressure on the vein above or below the phlebotomy. The unique feature of Mahorner's procedure is that the incision in the vein is closed with a running mattress suture of No. 0000 silk so as to reconstitute vein function. As a supplemental procedure, indirect regional heparinization is carried out by shunting the heparin solution into the deep veins through a plastic catheter placed in the saphenous vein at the ankle level. The shunting is effected by applying a tourniquet or a blood pressure cup around the leg just above the knee sufficiently tight to obliterate the superficial veins. The continuous heparin solution drip (200 mg. of heparin in a liter of 5 per cent dextrose) is allowed to run at about 20 drops per minute, the speed of the drip being controlled by the coagulation times. The shunting of the solution to the deep veins is done for 5 to 10 minutes every hour; the remaining time the infusion simply runs up the saphenous vein. Mahorner reports the cases of 6 patients who were so treated. In those patients in whom the thrombus was recent, brilliant results were obtained with rapid disappearance of leg swelling, very little late morbidity and minimum postthrombophlebitic edema. None of Mahorner's 6 patients had complications of pulmonary embolism either prior or subsequent to surgery.

Mahorner claims that his method restores the vein function with preservation of the vein lumen and vein valves. Postoperative venograms were not made lest they initiate a new thrombotic process.

In favor of Mahorner's procedure is the decompressive value of removing the thrombus from the vein centrally and peripherally. Lymph stasis and arterial spasm occur as a result of the inflammation within the vascular sheath. This inflammation rapidly subsides when the vein is thrombectomized. On the negative side of the procedure, I doubt if 5 to 10 minutes of heparin solution hourly through the deep vein is adequate protection for venous stasis in the calf and thigh. I suggest the application of an Ace No. 8 elastic bandage from ankle to knee, tight enough to compress the surface veins throughout the period of heparinization. In this way the heparin solution would be shunted constantly into the deep veins. The merit of this procedure probably rests in systemic heparinization. The procedure in no way prevents future attacks of deep vein phlebitis or protects the patient from embolic attacks should secondary deep phlebitis occur. Most lethal emboli come from the calf and popliteal veins where stasis is greatest. By femoral ligation at least a great part of the embolic problem is solved.

The principle of regional heparinization introduced into the dorsal vein of the

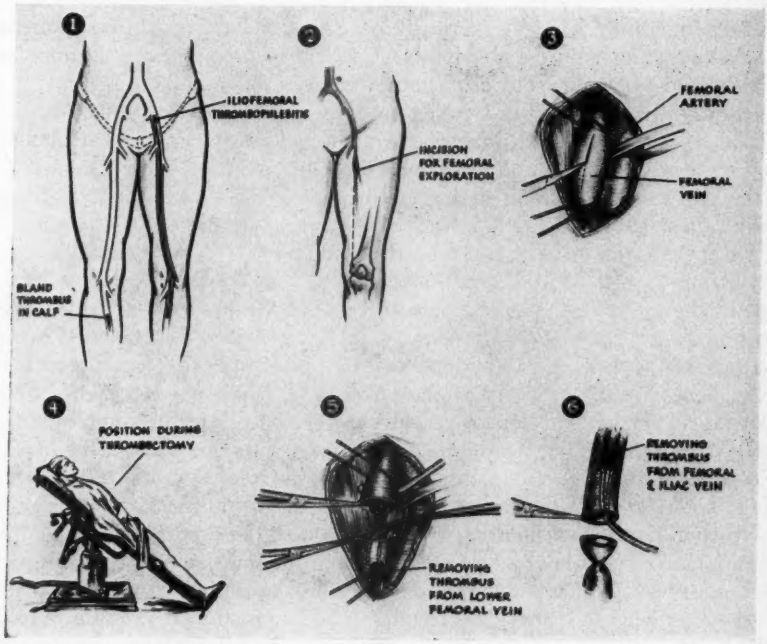

FIG. 3. Femoral vein thrombectomy and immediate regional heparinization. Thrombectomy is done with the table in reverse Trendelenburg position.

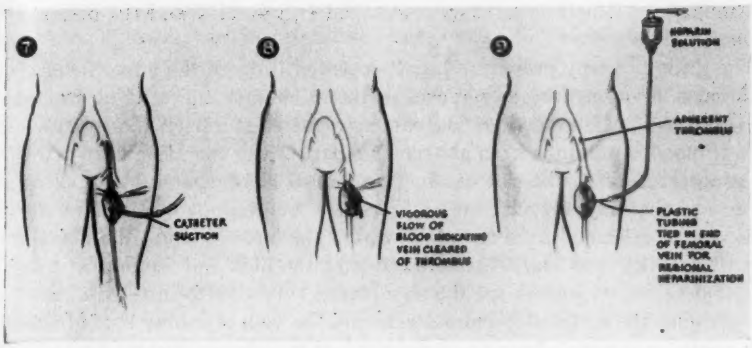

FIG. 4. Femoral vein thrombectomy and immediate heparinization. After all clots are extracted by forceps or suction a plastic tube is tied into the end of the divided superficial femoral vein and immediate regional heparinization instituted.

foot for deep and superficial thrombophlebitis has been reported by Blum.[2] Blum's patient became critically ill following a high saphenous ligation. There was evidence of inflammation in the operative wound, in the saphenous and presumably in the femoral vein. Eighteen hours following the introduction of a continuous infusion of heparin and penicillin into the dorsal vein of the foot of the affected leg there was a prompt lysis of fever and subsidence of the extremity tenderness and heat.

A method of direct surgery on the superficial femoral vein involved in thrombophlebitis that includes thrombectomy, ligation of the superficial femoral vein just distal to the femoral profunda and immediate regional heparinization through the proximal femoral stump is presented. (figs. 3, 4).

TECHNIC

Anesthesia has been either regional block including novocainization of the femoral and obturator nerves, or low spinal with pontocaine glucose hyperbaric solution. The patient is placed on the table with his feet resting on the foot rest so that he will not slide down off the table as the head of the table is elevated during the thrombectomy procedure—an important step in the operation, I believe. A vertical incision is made through the upper third of the thigh over Hunter's canal. Scarpa's fascia is incised and the sartorius muscle is retracted exposing the deeper layer of Scarpa's fascia which is similarly divided. The femoral vascular sheath is incised posteriorly and the femoral vein and artery are separated by dissection. Ligatures are placed, but not tied, several cm. apart about the superficial femoral vein near the entrance of the femoral profunda. The anterior wall of the superficial femoral vein is incised over the thrombus and the thrombus is allowed to extrude. The anesthetist now is asked to tilt the operating table as much as possible, usually at an angle of about 45 degrees with the head high and the feet low. An effort now is made to clear the peripheral portion of the superficial femoral vein of clots. Usually by forceps extraction, suction or manual milking, the vein can be cleared to the knee level.

The superficial femoral vein then is clamped and divided and the distal end is ligated.

The thrombectomy procedure now is repeated through the upper femoral and iliac veins. Suction, forceps removal, catheter suction and milking procedures are continued until no further clots can be extracted and particularly until a free flow of blood is obtained from above. This part of the operation may take 15 to 30 minutes, as often the clot has to be removed piecemeal and it is, of course, necessary that the thrombectomy procedure be thorough. When no further clots can be extracted from the upper end of the femoral, and when blood flows freely from the open end, it is believed that the iliac and femoral at least are free of detachable clots. A small gauge plastic tube then is inserted about 1 cm upward into the superficial femoral vein and the vein is doubly ligated about it. The wound is closed in layers with interrupted fine chromic catgut for the fascia, interrupted fine catgut for the subcutaneous tissue and interrupted fine silk for the skin. As soon as the plastic catheter is inserted in the femoral stump, regional heparinization is begun. The tubing is connected to an overhead flask containing 100 mg. of heparin solution in 1000 cc. of 5 per cent glucose in water. The heparin immediately is allowed to drip at approximately 20 drops per minute.

When the operation is being done for pulmonary embolism a prophylactic superficial femoral vein ligation is done on the opposite side.

As soon as the thrombectomy procedure has been completed, the operating table is returned to a level position and shortly thereafter into the Trendelenburg position to further venous flow. The patient is returned to his room with the foot of the bed elevated 12 inches. Regional heparinization with the same solution is maintained continuously for approximately 72 hours. Dicumarol is given by mouth as soon as postoperative nausea has disappeared. The patient is well controlled with dicumarol therapy by the time the regional heparinization is discontinued. The removal of the plastic catheter has been accompanied by no complications and no hematoma formation in the wound. An approximate coagulation time of about 12 seconds was maintained. No effort was made to attain the usual degree of anticoagulant therapy customary with systemic heparinization, the reason being that the constant addition of heparinized solution to the affected vein would prevent thrombosis even at low levels of systemic affect.

From 1952 through 1954 the author has used this procedure on 15 patients with femoroiliac thrombophlebitis or femoroiliac thrombophlebitis and pulmonary embolism. Eight of the patients were quite ill, having suffered one or more attacks of pulmonary embolism. The remaining 7 patients had active femoroiliac thrombophlebitis. In 4 patients thrombophlebitis coexisted in the varicosed saphenous vein and in the femoral vein. The thrombectomy procedure was done within 24 hours to 2 weeks from the onset of the clinical disease. When combined superficial and deep thrombophlebitis was present, the saphenous vein was operated upon in addition to the superficial femoral vein procedure. The saphenous vein was incised near its entrance into the femoral and the thrombus ex-extracted distally and proximally. It then was ligated flush with the femoral and the long saphenous stripped to the ankle using the external strippers.

There were no recognizable postthrombophlebectomy attacks of pulmonary embolism and no deaths. The procedure usually was followed by rapid subsidence of the inflammatory process and reduction in leg swelling. All 15 patients have remained under close postoperative observation and follow-up. Postoperative sequelae have been minimal although most of the patients have to wear elastic supports to prevent leg swelling.

The 15 patients in the group were not sufficiently dissimilar to warrant a report of each. It is probable that the mortality rate would have been high if vena caval ligation had been done in each patient.

The operative note of one case is presented as an example of the group: The leg was markedly edematous. There was an inflammatory reaction around the femoral vascular sheath and the artery and vein were intimately adherent to one another. The vein was completely occupied by a red poorly-organized thrombus. The thrombectomy procedure consisted of piecemeal extraction of thrombi measuring 1 to 3 cm. in length and a few mm. in diameter. These thrombi extended well up into the external iliac vein.

The author realizes that this is indeed a small series. It does, however, emphasize, we believe, that procedures other than inferior vena cava ligation can give remarkably good results in the surgical management of acute femoroiliac thrombophlebitis complicated by pulmonary embolism. It is reasoned that a clot that cannot be removed by careful forceps extraction, suction or milking, is not apt to be free and form an embolus. The high elevation of the head of the table adds safety to the procedure and often the complete clearing of the femoral vein is heralded by the sudden expulsion of the last portion of thrombus and a free flow of blood from above. Whereas, the continuous regional heparinization instituted at the time of operation cannot be expected to dissolve an overlooked thrombus, it can be expected to inhibit the development of additional thrombi on an overlooked adherent clot or on the roughened vein intima.

The advantages of the procedure may be listed as follows:

1. It is applicable to the very sick.
2. The surgery can be done without anesthetic risk, either by a regional block or a low spinal anesthesia.
3. Convalescence is quicker than from a caval ligation.
4. Thrombectomy, both peripherally and centrally, as done during the procedure results in decompression of the distended veins and thus has a salutary effect upon all circulation mechanisms, arterial, lymphatic and venous. This is in sharp contrast to vena cava ligation which in no way decompresses the iliac and femoral system distended with clot.
5. The postligation sequelae are definitely less than after caval ligation.
6. The procedure effectively prevents any further embolization from the calf vein level to the point of vein interruption and yet leaves intact the important femoral profunda and common femoral vein link for return of venous flow from the lower extremity. It is believed that it has, therefore, some of the advantages of the Mahorner procedure while offering greater protection against immediate or subsequent attacks of pulmonary embolism.
7. By placing the heparin solution where it is needed most and avoiding exces-

sive systemic heparin effect, the danger of hemorrhage is lessened. This is important when femoroiliac thrombophlebitis occurs in antepartum or postpartum patients or following surgical procedures prone to hemorrhage such as gastrectomy and vaginal hysterectomy.

8. By avoiding excessive doses of heparin and by instituting concomitant dicumarol therapy the heparin rebound phenomenon is avoided.

I have for a long time believed that anticoagulant therapy and repeated paravertebral blocks for acute femoroiliac thrombophlebitis leave much to be desired. The immediate results usually are gratifying but the postthrombophlebitic state is the invariable sequel. Contrarily, when pulmonary embolism, phlegmasia cerulia dolens, or contraindications to anticoagulant therapy, force one's hand and femoral vein thrombectomy is done, there usually is a rapid subsidence of edema and improvement of the entire thrombophlebitic picture. It would seem that a procedure so helpful for the complicated case would be applicable to the ordinary case. My present belief is that the operation for thrombectomy and regional heparinization should be done as an emergency in all patients who have acute femoroiliac thrombophlebitis and who are seen early before clot organization whether or not embolism has occurred.

SUMMARY

The author favors surgical intervention with the first indication of thrombophlebitis complicated by pulmonary embolism. The procedure preferred is a superficial femoral vein thrombectomy and regional heparinization on the affected side and a prophylactic superficial femoral vein ligation on the opposite side. The dictum that the only surgical procedure of merit is one that interrupts the venous system above the thrombotic process is denied. To subject a patient who is critically ill from pulmonary embolism to a major procedure when an operation of lesser magnitude would do the job does not seem justifiable. Caval ligation rarely is indicated and then only for recurring embolic attacks after superficial femoral vein ligation or for pelvic septic thrombophlebitis or phlegmasia cerulia dolens.

Time honored conservative management of femoroiliac thrombophlebitis with anticoagulant therapy and paravertebral blocks is questioned. A procedure, such as thrombectomy and regional heparinization that works so well for thrombophlebitis complicated by pulmonary embolism warrants further trial for uncomplicated femoroiliac thrombophlebitis. The author's present tendency is to treat patients who have acute femoroiliac thrombophlebitis who are seen early by surgical intervention.

When there is concomitant deep and superficial vein thrombophlebitis the author favors saphenous thrombectomy and ligation and stripping and superficial femoral vein thrombectomy and regional heparinization.

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AN EXPERIMENTAL STUDY OF THE LOCAL EFFECTS OF PERITONEAL DRAINAGE*

Awarded the Senn Medal for 1905 by the Surgical Section of the American Medical Association

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There is probably no detail in modern surgical pathology that deserves more thorough comprehension, but which is less definitely understood by the average teacher, practitioner, and student, than the nature of the reaction of the peritoneum to drainage; nor is there another that so often savors as strongly of pioneer mysticism, if expressed opinions, written or spoken, may be taken as criteria. This study, stimulated by the experimental observations here recorded, has been of such great interest and profit to the writer, that its publication was undertaken with the hope that it might be of some benefit to others. It is not presumed that the evidence here adduced should have any manifest effect upon the methods derived from practical surgical experience, but there may possibly result a more accurate understanding of both the possibilities and limitations of a most valuable procedure. An exact scientific, rather than an empirical, conception of any principle must lead to its more intelligent and efficacious application.

The subject-matter will be taken up in the following order:

I. History.
II. Reported Clinical Observations.
III. Reported Experimental Observations.
IV. Original Experiments.
V. Deductions.
VI. Practical Significance.
VII. Conclusions.
VIII. Bibliography.

I. HISTORY

A study of the history of surgical drainage with special reference to the peritoneum has, aside from its intrinsic interest, some importance in showing the development of modern theory and practice.

* The experimental work was done in the laboratories of Surgical Pathology of Johns Hopkins Hospital, Pathology of the University of Pennsylvania and Anatomy of the University of Chicago.

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Earliest Peritoneal Drainage. Hippocrates[1] first described drainage-tubes, or canulae, in advocating their use in the treatment of pleural effusions (empyema), and it was probably from him that Celsus[2] received his inspiration to treat similarly abdominal ascites. Celsus's tubes were not cylindrical, but conical, with the distal end of the greater circumference to prevent slipping within the abdomen. They were constructed of lead and brass, and were provided with plugs to regulate the outflow, as it was recognized that more than one sitting might be required to remove the fluid. Galen[3] and Avicenna,[4] in the second century, upheld this treatment for ascites, but it was not until the fourteenth century that the subject again received consideration, when Chauliaco[5] rediscovered drainage-tubes for the same usage. In the sixteenth century, Paré[6] figured tubes of gold and silver provided with a collar flange, and Ryff[7] again described similar instruments in the seventeenth century. Heister[8] and Scultitus[9] were both possessed of flanged metal tubes in the eighteenth century; the former apparently also used wicks in conjunction with the tubes, which seems to have been the earliest application of capillary drainage. At the close of this century, drainage must have been widely known, as Bell[10] laments the too common "putting by of solid and hollow tents."

Additional Indications for Drainage. During the first half of the nineteenth century but little if any attempt was made to treat other intraabdominal conditions than ascites by means of drainage, and the introduction by Fleury and Malgaigne[11] of rubber tubes within the metal to decrease the rapidity of outflow from the canula seems to have been the only innovation in this particular. At the close of this period the influence of McDowell's ovariotomy began to be more strongly felt. Operators were opening the abdomen with less hesitancy, and seeking faithfully, if painfully, for methods to reduce their discouraging mortality. While, at first, unconsciously applying a principle that was later to be discovered and rediscovered under the name of drainage, McDowell and certain of the other early "ovariotomists" did bring the long pedicle ligatures out through the abdominal wound—a menace rather than a safeguard. Sims[12] attributes the first extraperitoneal treatment of the pedicle to Duffin, at about this time, and this, also, has been regarded as a method of drainage.

As practical experience increased, it slowly came to be noticed that most of the fatal cases after ovariotomy, and indeed some that eventually recovered, showed an excess of serosanguinous fluid within the abdomen, which was prone to collect in the pelvis, particularly in the cul-de-sac. It was at first to the mere presence of this "secretion," and finally to its decomposition, that the fatalities were attributed. Septicemia from the absorption of this fluid came to be considered the common cause, as peritonitis was regarded as the exceptional cause of death (1:10, Sims). Keith well expressed the sentiment of the period in referring to "the red serum, that enemy of the ovariotomist," so generally was this view accepted. In the light of the times, it was therefore evidence that this secretion must be removed or prevented, and that by either secondary (curative) or primary (prophylactic) drainage. Thus arose the question of the ways and means of abdominal drainage and the indications for its application. As it is probably

only in the presence of ascites that continued peritoneal drainage is possible, it is easy to see how naturally the first workers in this field fell into error, and how well they were justified by a faulty theory yet to be practically disproven.

Rise and Fall of Secondary Drainage. The first attempt to remove post-operative collections of fluid from the cul-de-sac through the vagina was made by Peaslee[13] in 1854, in flushing the pelvis through the vaginal vault with plain water, and later with a weak solution of chlorinated lime. Thus was established the first peritoneal lavage and medication. Lande[14] attributes to him the first drainage of the peritoneum through the vagina, though this must have been done unwittingly, as Peaslee himself credits this to Keith in 1864, to whom Lande also gives the doubtful distinction of originating peritoneal drainage through the rectum. Wegner[15] in 1866 referred to drainage through the vagina as Sims's greatest contribution. At any rate, the introduction of soft rubber tubes into surgery by Chassaignac[16] in 1859 was a most important factor in the more general adoption of this procedure, and to each of these men, and also to Wells, is due the credit for popularizing a therapeutic innovation that, for the time at least, was of great importance.

Material and experience accumulated very slowly, but finally it was quite generally recognized that the expected was not happening and that the results of secondary drainage were far from being satisfactory. The secretions did not always or completely gravitate into the cul-de-sac, and even when this occurred, the tubes often failed to accomplish their removal, and were prone to become kinked, compressed, or the fenestra plugged with fibrin. Secondary drainage thus came more and more into disfavor, while at the same time there developed an increasing inclination towards the prophylactic. Just as vaginal drainage had been stimulated by Chassaignac's introduction of rubber tubes, now was primary abdominal drainage developed by Koeberlé's[17] use of glass tubes for this purpose in 1867, soon after followed by Keith and Wells. Koeberlé's tubes were shaped like a tenpin, with the base closed and provided with lateral apertures small enough (1 mm. in diameter) to prevent herniae of omentum or intestine. Keith's and Well's tubes were cylindrical, open at both ends, and also had lateral apertures.

The Popularity of Primary Drainage and its Decline. Sims's influence, which was largely instrumental in causing the adoption of that theory of fatal septicemia arising from the absorption of the dreaded peritoneal secretion, became ascendent about 1870. He employed primary drainage in his ovariotomy, but still used the rubber tube, which was introduced through the vagina and brought out in the abdominal incision. He[12] also tried a hard rubber tube, shaped like cock's spur, but with such an unfortunate result that it was discarded and a speculum-like, self-retaining silver tube devised, which, however, was probably never used.

Sim's reported clinical and post-mortem observations of the malignant blood-stained serum, confirmed by others and by his Sedan experiences,[18] turned the tide strongly in favor of prophylactic methods. It must be understood that there also was conservatism shown in both teaching and practice, notably by Gross, whose attitude won him the enmity of many of the enthusiasts. However, pri-

mary drainage became the fad. It was accepted enthusiastically by the German school, and by none more heartily, perhaps, than by Olshausen. Gradually, however, it, too, was found to accomplish less than was anticipated. The tubes did not always functionate satisfactorily. It was frequently noted that the lateral apertures became plugged with fibrin, but no one seemed to appreciate that the whole tube might as regularly be encapsulated in similar material, and when occasionally observed, it was considered a chance occurrence. Laparotomy came to be no longer considered *the* indication for drainage, even by many of its most enthusiastic supporters, including Olshausen, and eventually Sims himself. The use of drainage became limited to certain conditions, the nature of which provoked a discussion which is yet to be closed.

Reaction against Routine Drainage. This reaction against prophylactic drainage was greatly influenced by the growing recognition of the importance of antisepsis. Schroeder,[19] in 1875, declared that it was not the avoidance of the peritoneal secretion that was important, but the care not to infect it. In 1879, Loebker[20] maintained that inasmuch as the vagina could not be sterilized, a tube here was always dangerous. Although there was an increasing skepticism about the efficacy of the methods of drainage in use, there was no abatement in the efforts to overcome the obstacles to a lessened mortality and a more satisfactory convalescence. Many were the procedures devised. In 1880, Neuber[21] introduced absorbable drains made from decalcified pipe bones; Bardenheur,[22] in 1881, still loyal to drainage, surrounded a T-tube by a large mass of catgut, vainly hoping thus to promote drainage, prevent adhesions, and permit irrigation. Nichaise[23] recommended the use of red or black rubber drains, rather than the gray, which are more irritating, from containing an excess of sulphur. Lewis[24] used bundles of rubber thread, supposedly non-irritating, and easily regulated as to the size of the drain, both in introduction and withdrawal. Martin[25] following Miner's[26] reported subcapsular cystic enucleation in 1872, sought to render dangerous areas extraperitoneal by plastic operations or by the marsupialization of sacs; Mikulicz,[27] convinced of the physical and pathological impossibilities of ideal tube-drainage, emphasized the dangers of dead spaces, condemned irrigation through drainage-tubes, and began the evolution of his tampon by the freer use of gauze, in which last he was not alone, however, as Fritch and Sanger, among others, also used it extensively.

Introduction of Capillary Drainage. The lack of unanimity of opinion at this time is well exemplified by the ready acceptance of the theory of capillary drainage (gauze) when advanced by Hegar,[28] and secondarily by Kehrer,[29] as a solution of the problem. This Kehrer combined with tubular drainage, also inclosing the gauze in a rubber sheath to avoid adhesions, and employed a double tube to permit cleansing of the inner and the removal of the fibrin from the outer without withdrawing both at once, somewhat on the principle of the modern tracheotomy tube.

Subsequent Contributions. Henceforth little that was new was added to means or methods of drainage, though many more or less significant modifications were devised. Championiere,[30] in 1883, proposed the use of aluminum and celluloid tubes

and rediscovered hard rubber tubes. H. M. Sims,[31] in 1884, designed a double tube for combined drainage and irrigation; Binnie[32] used tubes of braided catgut, following the lead of Bardenheuer and John Chiene. The latter had used bundles of this material for capillary drainage in the peritoneum. (Various other materials have been used for this purpose,—glass wool, horsehair, silkworm-gut, asbestos, etc., but the authorship is obscure.) In 1885, Shaw[33] rediscovered that tubes should be flanged, and fashioned his after that on an outer tracheotomy tube. Bartlett[34] referred to Ellis's wire tube, but gave no description. Jenkins[35] found virtue in string as a tampon material as well as a means of cleansing the tube through which it was inserted. At this time—1887—Gersuny[36] advocated the use of iodoform wicks, and referred to those prepared with tannic acid used by Billroth. Chrobak[37] combined wick and tube drainage—a rediscovery of Heister's method. Wilson,[38] in 1888, described the (Philadelphia) Polyclinic spiral wire tube, very possibly on the same order as Ellis's. The next year, Beyer[39] made his absorbable tubes from animals' arteries, and Mikulicz[40] described his well-known tampon, which Wahler[41] found best applied through a cylindrical tube, which could also be used as a speculum when the gauze was withdrawn, and the cavity repacked through it if it was seen to be necessary. Hughes,[42] in 1892, described a rubber dam to be placed over the neck of a drainage-tube as a protection to the wound, neglecting entirely the discharge from about the tube. Maquire,[43] in 1893, referred to Morris's cigarette drains, made of gauze surrounded by oiled silk. Hardie[44] published the somewhat new principle of keeping a portion of the incision open temporarily by means of a device similar to a spring eye-speculum, with secondary tightening of the corresponding sutures after its removal, thus avoiding more than a superficial introduction of a foreign body. Kellogg[45] modified Eastman's well by inclosing the inner end of a drainage-tube within a larger tube, thinking thus to facilitate the outflow by preventing adhesions about the inner tube. Baldwin[46] wrote of Rushmore's method of roping gauze after the manner of wringing clothes. In 1898, Heaton[47] described a siphon drain, using the chemist's water-pump for creating constant suction from the tube. Ikawitz[48] described tubes closed at one end to be inserted into wounds for the purpose of catching the secretions (Secrets-auffänger). Bode,[49] in 1900, reverted, in his scheme for multiple incisions, drainage, and irrigations, to methods that had already proven fallacious.

In this brief outline it has been attempted to mention only the names of devices and methods in their chronological sequence, indicating roughly the necessities that mothered their invention, and alluding to such details as will be of subsequent importance in this paper.

II. CLINICAL OBSERVATIONS

The views of clinicians upon various phases of problems of peritoneal drainage are too numerous and varied for quotation. Those only will be cited which give a fair presentation of the questions under consideration, and these must be assumed to depend on equally accurate clinical observation. The proof of an established fact is not repeated. Other positive statements receive immediate or subsequent justification.

Conditions Governing Peritoneal Drainage. As affecting—

a. *Drainage through the Vagina.* The practical inefficacy and the actual dangers of this procedure have been so widely appreciated that it has fallen into general disuse, though some few operators still employ it in combating general peritonitis. (This has no reference whatever to such well-established methods as pelvic tamponade with gauze [and tube?] brought out through the vagina, as, for example, in vaginal hysterectomy, to pack off the field of operation, or in the drainage of pelvic abscesses [peritonitis] when opened through the vagina.)

b. *Tube Drainage through the Abdominal Incision.* This can only occur in obedience to natural laws, which are easily determinable. Mikulicz[27] recognized that if intraperitoneal fluid were to run out of a tube, there must exist a certain increased intra-abdominal pressure, vis-á-tergo, which could only be obtained by the application of dressings more tightly than an individual could endure, and, in addition, the tube must be constantly immersed in the peritoneal fluid (as high as the uppermost free orifice), which was impossible because of the immediate intimate application of the omentum, intestines, etc., to the walls of the tube, and the early formation of encapsulating adhesions. Kehrer[28] sought to amplify this by indicating the impracticability of using gravitation, through the impossibility of maintaining patients in a ventral position immediately after the operation, but this question had been already settled by the failure of vaginal drainage. He also observed that the secretion was too slow to permit the use of a siphon. The practical application of this principle "vis-á-fronte" Pozzi[50] attributes to Tait. The tubes were bailed out at frequent intervals, and many were the methods devised for doing this effectually and aseptically. The ultimate recognition of the uselessness of this practice, the patient's increased discomfort, and the danger of infection brought about its decline from general favor. The different kinds of tubes that have been introduced have, in part, been inspired by the idea expressed by Penrose:[51] "Theoretically, an aseptic, unirritating drainage-tube ought never to become shut off by adhesions from the general peritoneal cavity, since adhesions imply more or less irritation." Every tangible foreign body is a peritoneal irritant.

c. *Gauze Drainage through the Abdominal Incision.* The visceral and parietal serous surfaces become as immediately applied to gauze as to tubes. This is therefore the same problem modified by the differing physical characteristics of the drain. The outflow here is mainly by the vis-á-fronte (capillarity), and the rougher foreign body is more irritating. Kehrer, one of the earliest advocates of gauze drainage, confessed its limitations by enveloping his drain in rubber to prevent adhesions, and by using in conjunction with it a tube to provide escape for the material the gauze could not absorb.

d. *Combined Tube and Gauze Drainage through the Abdominal Incision.* The statements concerning (*b*) the tube and (*c*) the gauze need only be modified to suit the methods of combining these two forms, whether they are inserted side by side or the one partially or completely inclosing the other.

The Main Problem. The statement of our main problem is now permissible. If drainage of the general peritoneal cavity is possible, it is limited by—1. The time requisite to the functional seclusion of the drain through (*a*) the close appli-

cation of serous surfaces to the drain and (*b*) its subsequent encapsulation in adhesions; and also by—2. The physical laws governing (*c*) the removal of the drainage material from the tube, and (*d*) the restricted (absorption) capillary action of the gauze. The following evidence should be examined with a view to obtaining some solution of these questions.

The Duration of Abdominal Drainage. These observations are typical, and are based on the duration of the discharge, and not on its character. Ward[52] found that the flow from the tubes ceased in 12 hours, and from gauze in 24. Robb[53] considered that this varied from 12 hours to 5 days. Korte[54] found gauze strongly adherent in a patient who died 24 hours after the operation. Fowler[55] treated a case by Bode's method, and stated that through-and-through irrigation became impossible at 36 hours. In Hughes's[42] experience, tubes drained the peritoneal cavity 48 hours and the pelvis somewhat longer. Maguire[43] believed that abdominal drainage ceased in 48 hours. Tait[56] found irrigation through tubes impossible after 70–80 hours. Sanger[57] was of the opinion that drainage lasted 2 or 3 days. J. Price[58] observed a free exudate of blood for 10 days. Penrose's observations were antagonistic. In one case, irrigation became impossible in 22 hours; in another, which died 76 hours after operation, the serosa was free and dry. In addition, he quotes drainage of infectious and ascitic fluid that lasted from 3 to 11 days. M. Price[59] was of the opinion that so long as there was anything to drain it would run out, and, as evidence, quoted the prolonged (7 days) discharge from the drained site of attachment of an extrauterine pregnancy.

The results of drainage for the cure of ascites are quite different, but as this treatment is not in favor, little recent literature upon the subject is available. In 1886, Caille[60] reported two cases and quoted three observations of Jacobi's, all of which were in individuals suffering from cirrhosis of the liver. In one there was a discharge from the tube for nine weeks. Nine months later, at autopsy, there was "very little inflammatory reaction in the neighborhood of the puncture." Three other cases were similar, but one of Jacobi's was peculiar, in that the drainage resulted from a spontaneous rupture of the parietes near the umbilicus. All were temporarily benefited.

The subject-matter of the next section is so closly allied to that of the preceding, that they should be considered together.

Amount and Character of Material Removed by Drains. Allen[61] expressed surprise at the small amount removed by the tube in certain cases. Maguire[43] and Coe[62] both assert that pus and blood are not drained by gauze, nor can any but confirmatory statements be found in this connection. Coe further remarks: "Of course there is always a considerable discharge of fluid, but this is not the septic material we wish to remove." Mikulicz pointed out that the fluid drained is erroneously *not* attributed to irritation (of the drain to contiguous peritoneum), and this is well illustrated by Fowler's cases 3, 4, 7, in which the amount of fluid drained was directly proportional to the amount of drainage used; case 4, in which 21 wicks of iodoform gauze, distributed about the abdomen, not only soaked the dressings but also the bedding. In this connection, Dudley[63] may be aptly quoted. "If, as many claim, it is true that the presence of a drain excites the

secretion of fluid, that would not otherwise be secreted at all. It follows, then, that the drain is not so necessary as the large quantity of fluid it carries off would indicate."

There is abundant evidence in the literature that other than this watery fluid escapes from drainage, but this never comes from the general cavity, but directly from the drained areas. The free discharge from a localized peritonitis (encapsulated abscess) has no bearing upon the question of general peritoneal drainage. It, however, illustrates the conditions in a suppurating drain tract. All drain tracts are finally infected but the majority do not suppurate extensively.

Clark[64] found at autopsy that infected pockets occasionally occurred close to the drain tract, and also that the organisms causing the peritonitis might persist in the drain tract after they had disappeared from the general peritoneal cavity. This is of significance in illustrating what a drain does not remove.

A reconsideration of the main problem (*ante*) will insure a more discriminating examination of the succeeding clinical *data*. The time when drainage becomes (*a*) functionally inactive with respect to the general cavity as evidenced by the cessation of discharge is variable; in some cases it is less than 12 hours. Adhesions (*b*) which depend for their production on many extremely variable factors (the local and general condition of the patient, motility of the surfaces nature of the irritant, etc.), are even less determinable. They may, however, be established in less than 24 hours. The discharge from the tube (*c*) begins within the hour of its insertion, as shown by the old practice of bailing out the tube every hour the first day after operation; and (*d*) gauze acts only on the more watery secretions. (The ascites of cirrhosis affects drainage so obviously that it has only a passing interest beyond establishing the fact that continued drainage of the general peritoneal cavity is perhaps possible under certain unusual conditions.)

Two points are not clear: the cause of the early outflow of serum from the tube, and the reason for the cessation of this discharge. The primary serous discharge that all have noted must come from the peritoneum, and that subsequent to the operation and the institution of drainage. No matter what its origin may be, whether from the general peritoneum or from that portion directly irritated by the drain itself, to escape from the tube it must either exist in the general cavity in such an amount (practically an ascites) as to create its own vis-á-tergo and overflow, which has not been observed, or it must be formed in the immediate vicinity of the tube and thus escape in a path of least resistance. In other words, it must create a vis-á-tergo in a cavity determined by the functional seclusion of the tube, for in no other apparent way could the action of gravity be overcome. If, then, this primary serous discharge is due to the irritation of the tube to the contiguous serosa (an early inflammatory exudate), its cessation can be explained by the production of the fibrinous elements of the inflammation, for this would imply a marked diminution in the serous exudate, and consequently in the amount of drainage, provided there was no suppuration. The fibrinous exudate, in turn, would indicate the actual exclusion of the drain; i.e., the formation of an encapsulated drain tract. These are hypotheses which are equally applicable to gauze drains, but less obviously, on account of the capillarity.

Indications for the Institution of Drainage. If all the conditions which are believed to indicate the use of some form of a drain were to be literally followed, relatively few abdominal incisions would be entirely closed. Tait's dictum, "When in doubt, drain," has had great influence. Another weighty heritage of that time is the tendency always to attribute fatalities in undrained cases to the sins of omission, whereas the many evil results of the sins of commission are given much less consideration.

The indications for drainage most commonly accepted in modern practice are: 1. The presence, at the time of operation, of an established local or general infection of the peritoneum; 2. The probable subsequent development of such infectious processes; and 3. When, at the termination of operation, there remains material that cannot be spontaneously absorbed (blood-clots, cyst-contents, etc.).

In addition, there are indications for "packing" or tamponade held by those who distinguish between a drain and a pack, though they may use the same material for both, and by a much smaller number who have little or no faith in drainage. These indications depend upon "mechanical conditions of the peritoneum" (Mikulicz); viz., 1. Where there is, or is likely to be oozing or hemorrhage otherwise uncontrollable; 2. "Dangerous" areas that must be rendered extraperitoneal (abscess cavities, necrotic areas, certain ectopic gestation sac attachments, etc.); 3. To exclude areas that may become dangerous (enteroanastomoses, perforation sutures, choledochostomies, etc.); and 4. The obliteration of dead spaces.

This distinction between a drain and a pack is, in the majority of cases, wholly in nomenclature. The terms are often used interchangeably, and nothing is more perplexing to thinking students than to determine just how the peritoneum distinguishes whether it is being "walled off" or drained.

Methods of Drainage. Neglecting minor modifications, hard and flexible tubes, gauze, their combinations, posture effects, and lavage need consideration.

Those in favor of the hard tube are particularly fearful that the flexible tube may be displaced by peristalsis (Hyde[65]), or become kinked or compressed. Their opponents point out the very considerable danger of pressure necrosis and fistula formation (Korte[54]), no matter how carefully the hard tubing is introduced.

The believers in gauze drainage must concede to their numerous opponents the right of well-grounded opinion, clearly expressed by Coe: "Gauze acts rather as a tampon than a drain. If we use gauze at all, let us rather regard it as a hemostatic, or else insert it with the legitimate purpose of isolating septic surfaces from the general peritoneal cavity, favoring the formation of adhesions which will render the isolation permanent (?) after the tampon has been removed." The evolution of the modern cigarette drain, gauze enveloped in gutta-percha protective, is affirmatory evidence.

Combination tube and gauze drainage has its speculative and practical advantages. With the gauze inclosed there is possibly more rapid discharge of watery secretion, and if the gauze projects slightly from the end of the tube, it will act as an anchor in the prevention of displacement, while the tube may retard the formation of adhesions above. Such a drain can be removed with relatively little

discomfort. Gauze outside of a hard tube receives a firmness seldom needed, and, in turn, in forming a cushion makes pressure necrosis less likely.

The effect of the position of the individual upon drainage alone affects us; the questions of peritoneal absorption are quite distinct. All attempts to drain the peritoneal cavity from its lowermost part have been failures. Korte found that the method of draining the more dependent portions by multiple incisions beneath them was also useless for drainage, and, moreover, was harmful to the patient. This is probably the consensus of modern opinion.

Peritoneal lavage at the time of operation has little effect upon the reaction of the peritoneum to drainage. It is self-evident that if there were considerable solution in the cavity at the time of closure, it might have mechanical influence upon the relations of surfaces to the drain. The rapidity of peritoneal absorption is so great than any effect must be transient. Post-operative lavage can delay but not prevent the formation of adhesions. Once these have formed, peritoneal lavage loses its purpose, unless sufficient force is used to reopen the general cavity. Inasmuch as asepsis cannot be maintained in the presence of a drain, this certainty of the introduction of micro-organisms into an abdomen that is already abnormal is in itself sufficient to condemn the practice, unless it can be shown that the benefits obtained outweigh the dangers of infection.

Prevention of Adhesions. With the realization that drains provoke adhesions came futile attempts to prevent them, not only by multiplying the drainage methods, but also by increasing visceral motility. The use of salts for this purpose, probably introduced by Tait, was also advocated by Byford,[66] and Hughes[42] advised frequently changing the patient's position. Such procedures could only result in the dissemination of infection, even if they prevented adhesions. The least moved, the soonest mended, is a modified philosophy that is directly applicable here.

Avoidance of Drainage. Miner discovered the principle of the extraperitoneal treatment of intra- and retroabdominal conditions, that is still used to avoid intraperitoneal drainage. This is also attained by so-called peritonealization of surfaces denuded of their serosa and in certain abdominal cysts by marsupialization. The care with which a competent operator avoids injuring or soiling the peritoneum to curtail or escape drainage well demonstrates the modern tendency to limit its application.

Immediate Effects upon Patients. Nothing illustrates the fallacy of clinical observation more than the statements in this connection. One faction maintains that undrained cases have less post-operative discomfort. The other asserts the ease with which one may go from bed to bed and pick out the drained cases by the placidity of their facial expression. As a matter of fact, a drain is an irritating foreign body, and, as such, can scarcely be analgesic. Drains have also been held responsible for reflex nausea and vomiting (Clark[67]) and for constipation. The infrequency of these complications suggests an unfortunate, if unavoidable, application of the drain. The late development of post-operative peritonitis (one week) attributed by Munde[68] to drainage is too rare to be more than accidental or incidental.

Indications for the Removal of Drainage. All are agreed that when the discharge ceases it is time to discontinue drainage. This varies from 20 hours (Cartlege[69]) to weeks. Cushing[70] and Clark both removed gauze (in 4 to 5 days) when it becomes loosened. Clark attributes this loosening to a solution of the fibrin by developing granulation tissue. Intra-abdominal pressure rapidly causes the tract to collapse. Its size and condition determines, like ordinary sinuses, whether it must be kept open distally. Kocher's secondary suture of the wound after the removal of the drain finds but limited application.

Factors Governing the Disappearance of Adhesions. The formation of adhesions is modified by mechanical conditions. Their disappearance is due almost entirely to them; i.e., the motility of the adherent surfaces (Traube[71]).

The duration of the persistence of adhesions is not determinable, as it depends upon too many factors subject to individual variation—the extent and density of the adhesions, and the amount and constancy of the movements of the affected surfaces in contrary directions, and the force and amplitude of these movements. Penrose's cases are examples of the disappearance of adhesions. Two patients, treated for pelvic peritonitis, were drained—one for seven and the other for twenty-one days. At the end of two years and sixteen months, respectively, when re-operated upon, adhesions existed only between the omentum and ventral hernia sac. The method, form, and duration of the drainage and the after-treatment can evidently influence the disappearance of adhesions.

More Remote Effects upon Patients. The dangers of the subsequent development of hernia, fecal fistula, constipation, intestinal obstruction, ileus, and intussusception are only too well recognized. While their occurrence cannot be entirely avoided, it may be greatly limited by the application of the least dangerous method.

Objections to Drainage. These are as obvious as they are numerous, but, as Martin[25] has said, drainage cannot be entirely discarded. The most insurmountable objection to general peritoneal drainage is, however, noteworthy. From the time that Chassaignac's tubes were found plugged with fibrin, in the unconscious admission of Koeberlé that all serous surfaces applied themselves tightly to his tubes, when he made the apertures small enough to prevent herniae, and by the proof that Hegar's theory of capillary drainage by gauze was erroneous, and from clinical experience down to the present time, there has accumulated an array of facts that justify this main objection to general peritoneal drainage: it does not drain the general peritoneum.

III. EXPERIMENTAL OBSERVATIONS

These experiments have been physical and physiological, and there has been remarkable uniformity in the results obtained.

Capillary Drainage. (Extracorporeal experiments.) Thayer[72] compared the action of plain and iodoform gauze on water, and found that the plain took up water the more rapidly, and that both worked faster if the distal end was at a lower level than the proximal end, thereby adding siphonage to the capillary activity.

(This has been repeatedly advocated for clinical application.) Cigarette drains seemed to act more slowly even when the sheath of protective was fenestrated. McLean[73] obtained similar results with the use of Richardson's artificial serum. He found, in addition, that moderate pressure upon the gauze has but little effect upon capillary activity. Gauze did not take up pus. Piskachek[74] compared the activity of gauze and braided cotton wicks of equal size. The wicks drained three times as much water in 24 hours, and also acted a little longer. He, too, observed that siphonage added to the rapidity of the capillary action, but that this might be also attained by enveloping the distal end of the drain in dry gauze, which is obviously the effect of surgical dressings.

Experiments on Cadavers. Helvetius (quoted by Sänger[75]), Delbet,[76] and Mikulicz, injected water into the abdominal cavity, and found that it would never entirely run out again through drainage-tubes. Various attempts were made to simulate conditions of the living body, but with the same results which also followed the exertion of abnormally high pressure. The tubes were always blocked by the application of viscera to the apertures. Mikulicz controlled this by placing coils of inflated human intestine in a basin having an outlet through the bottom. Water then poured into the basin would never completely escape before the outlet became plugged by an intestinal loop. The use of a drain-tube gave similar results. With the aid of colored solutions it was found that none of the pre-existing solution, and not all of that secondarily injected, could be recovered from the tubes. Delbet[77] thus also showed that the irrigating solution reached all parts of the peritoneal cavity. This probably implies the use of considerable liquid, as the peritoneal surface is so extensive. According to Wegner's measurement, it is about 98 per cent of the skin surface.

Experiments on Living Animals. Preliminary to the consideration of the work done directly upon drainage problems, certain observations are cited as explanation and proof of subsequent statements.

Graser,[78] in a very thorough histological study of peritoneal adhesions, arrived at some noteworthy conclusions. Fibrin is concerned in the formation of every adhesion. The more active the inflammation and the greater the endothelial destruction, the more fibrin is produced, except occasionally in the presence of suppuration, when it may be undemonstrable (digestion?). The serosa cells may disappear through abrasion, desquamation, or cytolysis. Simple continued approximation of serous surfaces does not produce adhesion. There must always be some slight irritation. Exposure to dry air for twenty minutes is sufficient to produce them.

The variation in the severity, nature, and duration of the irritation determines the nature of the resulting adhesions. For example, Elting and Calvert[79] observed in dogs that the adhesion following an infectious peritonitis were weaker, and disappeared sooner (three weeks) than those due to severe temporary but widespread mechanical irritation (organized connective tissue at five weeks).

Eventual infection of the drainage-canal is the rule. Councilman[80] attributes this to the lowered resistance produced by the foreign body along which the skin

cocci are prone to travel. Robb and Ghriesky[81] examined the drainage-tube secretion in sixteen laparotomy patients, and even this was infected in seven—six times with the staphylococcus albus and once with staphylococcus aureus.

Wegner's[15] classical experiments showed a dog's peritoneal cavity to be capable of absorbing water at the rate of 3 to 8 per cent of the animal's body weight in an hour, and that under proper irritation it would exude serum with equally marvelous rapidity. In addition, it is probably a fair pathological assumption that fibrinous peritoneal exudates are constantly preceded by serous exudates.

Drainage Experiments on Living Animals. Van Ott's[82] work in 1878 was done at a time when the question of prophylactic drainage was not definitely settled, and, like much else that lies buried in laboratory annals, his results were capable of profitable clinical application. He inserted through-and-through soft rubber tube drainage in rabbits in such a manner that the tube could, seton-like, be pulled forward and backward. The tube was provided with a string within its lumen, so that coagula might be readily dislodged. Twice a day the string and tube were both moved, and then a two-per-cent chlorinated lime solution was injected into the tube. His results from observation of the living rabbits, or of those dead and killed at intervals, are embodied in the following conclusions:

1. Adhesions usually surrounding the greater part of the tube formed the first day.
2. The tube was isolated from the general peritoneal cavity in three days at the earliest.
3. Serous discharge lasted only one or two days, when suppuration began.
4. Suppurative peritonitis did not occur. Therefore the pus came from the newly formed capsule in the walls of which abscesses occasionally occurred.
5. Neither moving the tube nor injecting into it prevented enveloping adhesions.
6. After the third day injection of the peritoneal cavity was impossible.
7. Discharge of fluid from the general peritoneal cavity did not last 24 hours.

Heinricius[83] repeated von Ott's work, and confirmed both his results and conclusions.

Delbet, in 1889, reported the results of his experiments upon dogs, done under more modern conditions, and imitating as far as possible those of practice. These are given in very brief outline: (*a*) Glass tube placed in the pelvis; two days later, water injected intra-abdominally through another opening did not escape from the tube until the adhesions were broken up by high pressure. (*b*) Another tube-drain was found at the end of two days completely enveloped by omentum, and no "false membrane" was present. (*c*) Two drains—one glass tube and one rubber tube—used. On the third day there was considerable discharge. Dog killed; both drains found walled off; the discharge was therefore from the false membrane (adhesions). (*d*) Two drainage-tubes, glass, and rubber again used. At the end of 24 hours 100 c.c. salt solution injected into the rubber tube. None returned. Animal killed next day. Tube enveloped in omentum. No other adhesions. Eight other similar experiments with glass and rubber tubes and gauze all resulted in

the complete walling off of the drain in 48 hours, unless enveloped by omentum, when there was no (other) peritoneal adhesion.

From the results of these experiments Delbet drew the following conclusions:

1. The function of drainage-tubes is contingent upon the obstruction of outlets by intestinal coils.
2. Tubes may become filled with coagula.
3. Capillary drains avoid this, and are therefore superior.
4. Adhesions rapidly form about aseptic drains, isolating them from the general peritoneal cavity.
5. Effectual and durable drainage of the general peritoneal cavity is impossible.
6. Serous discharge comes, in the majority of cases, from the tract about the drainage.

Comparison of these experiments shows that when the variations in methods and in animals are considered, the results are practically identical in their significance. No fact established is in disagreement with legitimate deductions from clinical observations. Our problem can now be restated in a considerably modified form. General peritoneal drainage is a physical and physiological impossibility, because of the functional incapacity of the drain through (*a*) the early application of serous surfaces to the drain secluding it, and (*b*) the subsequent formation (in less than two days) of an encapsulating sheath of fibrinous exudate and adhesions excluding it from the general peritoneal cavity. The drain discharge is the result of an inflammatory reaction flowing out in the (drainage) path of least resistance, from (1) a potential cavity formed by close approximation of serous surfaces, which later become (2) an actual cavity by the action of a plastic fibrinous exudate forming encapsulating adhesions. The nature of the drain is of but relative importance in determining the degree of irritation and the extent of the consequent inflammation. After the drain-tract has once become an extraperitoneal cavity, the physical qualifications of the drain may have a material influence upon the rapidity of discharge.

IV. ORIGINAL EXPERIMENTS

These experiments were done so nearly in the same way that by neglecting the individuality of the animals the results become directly comparable. Dogs were invariably used and treated, so far as possible, like human patients, in order to make the experience gained susceptible of some clinical application.

Methods. Morphine was given hypodermically, in 1–2 grain doses, according to the size and age of the dog. This made the subsequent ether anesthesia easier, produced prompt emesis and catharsis, and made the postoperative recovery more gradual and more comfortable, eliminating vomiting, and probably decreasing peristaltic activity. Muslin swathes were applied so as to include the whole body, the legs projecting through holes of proper size and shape, and provision being made for the escape of urine and feces. Binders thus applied snugly remained in position, caused no discomfort, and, besides protecting the wound, gave ample support to the abdomen and dressings.

The drains were made the same shape and size, unless very small dogs only were available, when they were somewhat reduced. The gauze, iodoform, bismuth, or plain, was always inserted rolled in the form of a stogie, or with a sheathing of protective, as cigarette drains, so that its effect and that of the tubes should be similar. The drains were therefore

approximately the same in size, about 7 cm. long and 4 cm. in circumference, but varied in material and flexibility. The method of insertion was the same. The omentum was always displaced as far upwards toward the diaphragm as possible, and the drains placed downward between the intestinal coils. The incisions were closed snugly about the drains to prevent their displacement. No particular attention was paid to the after-treatment. Water was always provided, but no food was given to animals that were to be killed in a few hours. Ether or chloroform was used for this purpose, but always provoked such active resistance that the strength of intra-abdominal adhesions was severely tested. In the last few experiments it was found that illuminating-gas was far more satisfactory, death was rapid, and almost without discomfort. It is easily administered through a small glass funnel connected by a rubber tube to a gas-fixture.

In order to establish, ante mortem, whether or not the drains were still capable of carrying off intra-abdominal fluid, the dogs were again anesthetized and incisions made just beneath the ensiform, and salt solution, stained red with Orth's lithium carmine, injected by means of a long tube and funnel. The head of the table was elevated, and sufficient liquid introduced to produce dullness above the level of the drain. As a control, a similar drain, similarly inserted, was often employed. Any escape of fluid along the drain could be sponged with dry gauze and its nature determined.

To avoid confusion, the experiments are numbered in sequence as recorded. Controls were made in every instance where there could be any reasonable doubt as to the validity of the observations. Two forms of drains were often tried on the same animal, so that not only was the comparison more accurate, but each, in a way, controlled the other.

Physical Experiments. The capillary action of gauze upon pus (empyema), a highly albuminous exudate (tuberculous peritonitis) and a slightly albuminous transudate (ascetic fluid) was tried. The transudate was taken up rapidly, the exudate slowly, and the pus not at all.

To test the rapidity of absorption by gauze, Orth's lithium carmine was used, being more quickly taken up than other stains at hand, and not precipitated. The rapidity of absorption of certain forms of drain was tried. Taking gauze stogies rolled equally tightly, it was found that the smaller the stogies and the deeper the immersion, the more rapid the absorption. Damp and dry stogies were compared. The dry absorbed the lithium solution more rapidly, but the moist took up a greater volume. Four cigarette drains were made with the protective snugly applied in two and four layers, two with the gauze protruding from the lower end, the other two with the protective folded over the gauze and firmly tied in place. These were controlled with stogies made like the gauze within the cigarette. The cigarettes absorbed more fluid with equal rapidity, but it is, of course, possible that if uniformly compressed, as when within the abdomen, this might not follow. No comparison of the rapidity of absorption of bismuth and iodoform gauze was attempted, as the indications for the practical use as hemostatic, and to provoke adhesions, would make any question of the capillary action of minor consequence.

Physiological Experiments. In the descriptions, stogie drains are referred to as gauze and cigarette drains as protective. Iodoform, bismuth, and plain gauze have been used indiscriminately, as there was no appreciable difference in their effect.

Reaction of Normal Peritoneum to Drains

SERIES I. *Experiment 1.* Right rectus incision; gauze drain inserted at upper and protective at lower angles of wound. After seven days the protective tract was smooth, moist, and firm. The lining was composed of yellowish fibrinous material. No bleeding followed the withdrawal of the drain, which was easily done. The gauze tract was similarly complete. Removal of the gauze drain-required force, caused bleeding, and was followed by the discharge of a reddish viscid secretion (cultures negative). The intestines, mesentery, and omentum were involved in the adhesions. The balance of the peritoneum was normal.

Experiment 2. Same as above. The omentum was displaced upward with more care. Dog

was killed after 4 days. Protective tract was smooth, moist, and firm. Protective was easily withdrawn. Gauze tract also complete, but drain was adherent. Force required to move drain sufficient to break down the adhesions, thus opening the peritoneal cavity. Adhesions extended 5 mm. from drain, becoming progressively less dense. Again noted that adhesions about protective appeared more like fibrin than granulation tissue.

Experiment 3. Same as above. Dog was killed after 3 days. Results were similar. The peritoneal cavity again opened when gauze was removed, and granulations were adherent in its meshes. Viscid reddish secretion was present in the tract. Peritoneum away from drains was normal.

Experiment 4. Same as above. Practically the same conditions were found after two days. The gauze was even more adherent and its imprint remained on the granulations. Same viscid material was in the tract.

Experiment 5. Right rectus incision. A small rubber tube was inserted into the gall-bladder and fixed by a purse-string suture, inverting the serosa. Tube and apex of gall-bladder were enveloped by folds of protective. This was brought out low in the incision, in an attempt to surround the drain with intestines. Tube and protective were easily and painlessly removed two days later. The fistulous tract was intact. It drained two days and then closed spontaneously. The dog remained well.

Experiment 6. Left flank incision. Polyclinic helical wire drain inserted. Dog killed in 24 hours. Drain tract was water-tight. General peritoneal cavity was normal. A fibrinous exudate not only completely filled the spaces between the wire loops, but partially plugged the tube itself. Superficial dressings were moist but drying.

Experiment 7. Left flank incision. Glass tube with small lateral orifices and closed base was used. Dog was killed in 24 hours. A fibrinous exudate less extensive than in experiment 6 was found, and the tube contained none. A greater secretion of serum had occurred, as indicated by more moisture in the dressings. Apparently, there was a freer discharge about the tube than the wire. The general cavity was normal.

Experiment 8. Same as above, except that soft rubber tube with small lateral openings was used. After 24 hours the results were the same as in experiment 7. Lateral apertures were plugged with fibrin. General peritoneal cavity was normal.

Experiment 9. Incisions in both flanks. Protective drain applied in the right, gauze in the left. Dog was killed in 24 hours. Both drains were completely walled off. There had been a more copious discharge of serous fluid from the protective. Carmine solution was used, and the gauze remained unstained. It was noted that the adhesions had formed not merely between the drains and the serous surfaces immediately in apposition, but had already extended by continuity, as it were, along these surfaces to involve others in immediate contact with them. It was remarkable how much greater had been the reaction on the omentum and mesentery than upon the intestines and parietes.

Experiment 10. Right flank incision. Gauze drain applied. Dog was anesthetized after 18 hours, and a similar drain inserted in a corresponding position in the left flank. Save for a slight excess of clear fluid, the peritoneum was normal. Carmine fluid was then injected beneath the ensiform, according to the method described. It appeared at the left drain in a few minutes, but there was no leakage from the right in forty minutes, though more solution was constantly added, and at the end the intra-abdominal tension was such that the red solution gushed out of the subensiform incision with each respiration. There had been considerable serous discharge from the drain, as shown by the gauze dressing, but this had ceased some time previously, as the gauze next to the skin and even the end of the drain itself had become quite dry. At autopsy the drain was found to have become entirely extraperitoneal by adhesions of the intestines and omentum to each other, and the parietal peritoneum.

Experiment 11. Same as above, except that a protective drain was used. When the test solution was injected there was an early escape of the fluid, both through and about the control protective drain, showing good drainage either way. No fluid escaped from the primary drain. The serous discharge had been copious, but had ceased. At autopsy, ad-

hesions were found to consist of omentum and parietal peritoneum. The drain was thus entirely encapsulated. (The conditions here were also observed in other experiments, and indicate better immediate drainage from the protective. If the drain is made too stiff and the abdomen is not well supported, there may be a weaker place in the adhesions between the viscera and parietes, particularly when this is not formed by omentum.)

Experiment 12. Right rectus incision. Gauze drain inserted at the upper angle, protective at the lower. Dog killed after 14 hours. No carmine solution used. In the manipulations attendant upon the abdominal examinations, both tracts were broken down, but they had evidently been complete, as the previously adherent areas could be easily recognized, not only where there had been actual contact with the drain, but the immediately adjacent surfaces were thickened and congested. These changes were always most advanced on the omentum, and more so on the mesentery than on the intestine. There was a decidedly more marked reaction about the gauze than the protective. The omentum seemed to penetrate and become adherent within the gauze meshes.

Experiment 13. Right flank incision. Gauze drain inserted. Dog etherized after 12 hours. The carmine solution was used. Almost immediate escape of fluid from control gauze. None had appeared from the primary drain after 15 minutes, when the dog was killed. Adhesions of intestines and omentum had completely encapsulated the drain. The gauze was nowhere stained by the carmine. Reaction similar to that of 18 hours, but less extensive.

Experiment 14. Same as above. Protective drain used. Dog etherized in 12 hours. Same results with carmine solution. At autopsy, adhesions were entirely omental, in spite of extraordinary precautions to prevent this. This illustrates a repeated observation. The protective, being very slippery when moistened with peritoneal fluid, offers less resistance to the omentum which, by its mobility, easily comes to envelop it completely. The resulting reaction is the same as if the drain were inclosed by several structures, except that there is no extension of inflammation away from the surfaces apposed to the drain (a manifest advantage if other things are equal).

Experiment 15. Incisions in both flanks. Gauze inserted in the right, protective in the left. Dog killed in 8 hours. Both drains water-tight, and both were enveloped by omentum, but entirely extraperitoneal. There had been the usual amount of serous discharge, which had apparently ceased, as the gauze on the peritoneum was driest nearest the skin about the wound. There was a considerable fibrinous exudate upon the omentum, but this was more extensive at the margins of the incision where the drain had been held constantly in contact with the parietal peritoneum. (Other experiments done without the injection of the fluid showed the same thing.) These adhesions, while unmistakable, are broken up with the greatest ease when manipulated.

Experiment 16. Same as above. Secondary observations made in 6 hours. Here an excess of intraperitoneal fluid was present. There were no signs of a general peritonitis. Drains discharged none of the test solution under considerable pressure, and again the drains were completely enveloped in omentum. Changes were less marked than in experiment 15, and the adhesions were far less resistant. As before, the greatest reaction was at the margins of the incision about the drains. The gauze dressings were more moist than in experiment 15, but there was the same drying near the wound. (Controls at this period indicate that there is a definite exudate formed by this time, causing adhesions sufficient to wall off the drain, but that these are extremely delicate and easily disrupted by any considerable increase in intraperitoneal pressure.) If the drains are too large and stiff, so that there is constant motion from respiration, there may be no adhesions, but only a reddening of the serosa most constantly in contact with the foreign body.

Experiment 17. Same as above. At the end of 4 hours there was found a greater excess of clear peritoneal fluid. The control solution escaped freely from both drains almost immediately. There was injection, and a distinct exudate upon the parietal peritoneum at the margins of the wound. The intestines and mesentery were free. The omentum was adherent to both the gauze and protective in places. The gauze dressings were moist, but by no means wet. (Controls gave practically the same result. In one other case the gauze dressings were appreciably dry.)

Experiments 15, 16 and 17 were done in one day, so that relative changes were more striking. The greater excess of peritoneal fluid in the shorter interval is of considerable interest, as well as the regularity with which the most advanced reaction appeared on the parietes where there had been constant apposition of the drains.

Gross Pathological Changes. There is at first a serous exudate associated with local hyperemia. As the inflammatory reaction increases, a fibrinous exudate is formed and there is more intense local congestion and some edema. The serosa loses its luster and is finally covered with opaque plastic fibrin. This fibrinous surface persists in the presence of smooth drains for at least seven days. Gauze, however, acts differently. The fibrin becomes incorporated in its meshes, followed by an ingrowth of granulation tissue, so that when the gauze is removed, instead of leaving a smooth yellowish surface it is rough and bleeding, with fibrin and superficial tags of granulation tissue still clinging to the more superficial portions of the gauze.

The serous exudate is most abundant during the first few hours (4 to 6), when it becomes noticeably less in amount, and concomitantly there begins the visible deposit of fibrin. This serous excess is manifested during this time by the wetting of the abdominal dressings, and by the appearance of an increased amount of intraperitoneal fluid, which disappears about the time the isolation of the drain by adhesions is effected.

The character of the adhesions varies with the nature of the drain; the greater and more prolonged the irritation, the more intense the reaction and the firmer the adhesions. This, however, appears in no way to influence the rapidity of the formation of the adhesions nor the completeness of the resulting encapsulation. All serous surfaces, visceral or parietal, react similarly, but vary in degree, apparently directly with the richness of the blood-supply, and inversely with the amount of intrinsic motility and structural firmness.

Minute Pathological Changes. Tissue was taken from the drain tract at various periods. The study of the material histologically showed that the reaction processes were practically the same for each variety of drain, but differed in extent, as above noted. One description is therefore sufficient, and, with that single reservation, is applicable to all the conditions studied.

At four hours there is a congestion of the superficial vessels, with diapedesis of red-blood corpuscles and migrations of polymorphonuclear leucocytes in small numbers. A slight, delicately meshed serofibrinous exudate is present, containing these cells in limited numbers, and also a very few desquamated serosa cells. By six hours the exudate is well established, and is no longer easily displaced in the process of preparation. The vessels are more widely and intensely congested, and the exudate is slightly more cellular, but not proportionately to the increased interstitial migration of the leucocytes, which in 8 hours have become amassed in a layer in the more superficial tissues beneath the serosa.

These changes gradually progress with the lengthening periods. The exudate becomes denser and more cellular. It is remarkable to what a slight degree the serosa is affected. The subserosa becomes thickened by cellular accumulations and vascular injection. At 24 hours all these changes are pronounced. The fibrin in the exudate is dense, and the individual filaments coarse, and they have increased relatively faster than the cellular elements, which are present in large numbers In the 48-hour specimens, the changes, though still more advanced, are similar, and there is as yet no evidence of fixed tissue proliferation. This appears fairly constantly at 72 hours, particularly in the omentum, and is characterized by the presence of fibroblasts and the "sprouting" of capillaries. The leucocytes present in large numbers are beginning to degenerate. (This probably explains why gauze drains become loose after a few days, the breaking up of the leucocytes giving rise to ferments that digest the fibrin enmeshed in the gauze. Later the granulations grow into the gauze again, fixing it even more securely.) With the more advanced periods comes a progressively more mature connective tissue development.

The changes on the omentum and mesentery are constantly more rapid than on the intestine, and more extensive. There is also a very slight variation in the character of the exudate. That upon the intestine contains relatively more leucocytes, whereas the serosa cells are more numerous in that upon the omentum and mesentery. The smooth drains,

particularly the protective, possibly provoke an exudate slightly richer in polymorphonuclear leucocytes. These variations are not significantly extensive.

The surface of the exudate apposed to smooth drains is correspondingly even; that next to gauze is rough and shaggy, and filaments of cotton fiber are not infrequently present in such sections.

Reaction of the Peritoneum in the Presence of Infection. The experiments in series I were done under conditions of relative asepsis. Cultures taken from the peritoneal cavity when the abdomen was secondarily opened were constantly negative. Those from the drain tract, at times negative, frequently contained a staphylococcus albus. To determine the influence of infection, the following experiments were undertaken. A 24-hour bouillon culture of staphylococcus aureus of a limited but constant virulence was used. It was given in doses of 5 cc., usually suspended in 5 cc. of salt solution. When not introduced through an incision, it was injected through the parietes at a level lower than the drain.

SERIES II. *Experiment 18.* 5 cc. of a bouillon culture with 5 cc. saline solution was injected intraperitoneally. Symptoms of toxemia followed, but none of peritonitis. There was complete recovery. (Control, 36-hour culture used. Results were similar. Dog killed in 3 days. Peritoneum was slightly congested and the peritoneal fluid was somewhat cloudy.)

Experiment 19. Right rectus incision. All manipulations of introducing a gauze drain carried out, but the drain was withdrawn and the abdomen closed. Cocci then injected as above, with similar results. Dog killed in 6 days. Omentum adherent to the scar. No peritonitis.

Experiment 20. Right rectus incision. Gauze drain of usual size placed between intestinal coils, but not brought up to the incision, which was completely closed and the organisms injected. Usual symptoms of intoxication followed, and slight abdominal tenderness over region of gauze. Dog killed in 44 hours. General cavity contained slightly turbid fluid. Peritoneum congested, but smooth and shiny. The gauze was completely encapsulated by adhesions, and this cavity also contained a thin, cloudy exudate. (A control killed in 72 hours showed same local conditions, but the general cavity was normal. Another control with 36 hours' culture was followed by death from intense hemorrhagic peritonitis.)

Experiment 21. Same as above, except that a similar sized piece of sterile potato was introduced. Practically same results were found. Cavity about the potato contained a larger amount of thicker, purulent material. (A control produced a mild general peritonitis.)

Experiment 22. Right rectus incision. Gauze drain inserted; wound closed; the culture then injected. Signs of intoxication and local tenderness. Dog killed at 72 hours. General cavity normal; drain tract complete.

Experiment 23. An intraperitoneal injection of culture followed by symptoms of intoxication and slight abdominal tenderness and rigidity. Laparotomy on the fourth day. Fibrino-purulent peritonitis (pure culture of aureus) was present. Iodoform gauze introduced into the left flank; plain gauze into the right. Dog killed in 10 hours. Both drains were completely encapsulated. (Similar observations indicate that a pre-existing non-fulminant peritonitis has no influence on the formation of adhesions, other than possible acceleration.)

Experiment 24. Left flank incision. Gauze drain applied, followed 15 hours later by an injection of the culture. Dog killed 10 hours later. Drainage had ceased. The peritoneum was normal. Drain completely encapsulated. Cultures from general cavity gave aureus and bacillus subtillis. Those from the drain tract were negative. Other experiments of this nature upheld the findings of series I, but were less accurate, as contamination of the drain for the general cavity could never be excluded, owing to the slight resistance of adhesions to manipulations.

In these experiments the question of individual resistance was prominent and complicating. Dogs that developed general peritonitis in the presence of a foreign body showed the most intense inflammation nearest the encapsulating adhesions. The development of peritonitis in the absence of any foreign body, and the absence of general peritonitis when foreign bodies were present, modify conclusions that might be otherwise inferred. Nevertheless, it must be assumed that the presence of a foreign body is detrimental to peritoneal

resistance. An assumption then that inflammatory reaction resulting from the presence of a foreign body enhances the power of local resistance to infection is not justified, from the fact that in the presence of normal resistance and the same infection there is comparatively slight reaction, general or local about the point of inoculation.

Bacteriological studies by culture and cover-glass show that where the foreign bodies were walled off in the presence of infection the micro-organisms persisted within the adhesions. So long as the general cavity contained cloudy fluid, organisms were demonstrable, and even after this, when the peritoneum appeared normal, they might be found as long as 72 hours on the under surface of the omentum.

The more intense reaction immediately about foreign bodies completely within the peritoneum is attributable to the greater pressure within the adhesion capsule, but they are probably little more liable to predispose to general peritonitis, excepting that these adhesions are more likely to rupture into the general cavity, having no path of lessened resistance leading externally.

Observations on the Resorption of Adhesions. The determination of the duration of adhesions is of little importance compared with the recognition of the factors concerned in their disappearance. In these experiments it was impossible to be certain what structures became involved in the adhesions without a secondary operation, which was found impracticable, as it added indeterminate complications, but every justifiable precaution was taken to prevent complete omental envelopment of the drain.

SERIES III. *Experiment 25.* Left flank incision. Gauze drain inserted and removed after 3 days. Twelve days later the dog was killed. Omental adhesions to the parietal scar alone remained.

Experiment 26. Similarly done. The gauze removed 7 days later. After 12 days, autopsy showed omental adhesions to scar and a small organized band extending to one loop of intestine.

Experiment 27. Similarly done. The gauze was removed in 5 days; 14 days after, adhesions between omentum and scar alone remained.

Experiment 28. Right rectus incision. Gauze drain placed at the upper angle, protective at the lower. Drains removed 7 days later; left rectus incision after 35 days. Omentum and superficial loop of intestine adherent to parietal scar, but not to each other Nephrotomy and nephrorraphy done through the rectus incision. Large cigarette drain to kidney, at the base of which the gauze protruded and was spread over the kidney. The drain was brought out along the parietal peritoneum, through the incision, and removed in 2 days; 10 days later omentum and superficial intestines were still adherent along the drain tract, which remained firm and patent. The stomach and spleen were involved in a mass of perirenal adhesions.

Experiment 29 (Experiment 5, First Series). Cholecystostomy. Protective and tube for drain 2 days, discharging sinus for 2 days. Necropsy 13 days later. Omental adhesions present along parietes. The lobes of liver were adherent to each other and intestinal adhesions persisted about the gall-bladder.

Experiment 30. Right rectus incision. A proximal loop of small intestine was secured, bent on itself, and laterally approximated by two parallel rows of silk sutures about 3 cm. apart, and perpendicular to the long axis of the bowel. Care was taken to avoid touching the serosa thus approximated, and to avoid all possible bleeding from the stitches. This portion was replaced and the same thing done to a more distal loop. Between these rows of sutures a cigarette drain was placed so as to extend down to the mesenteric insertion. A similar drain was also introduced between coils of free intestine, the omentum was then pushed upward, and the wound closed with the drains fixed at either angle. These drains were easily removed three days later. Eleven days subsequently the dog was killed. No traces of adhesions about the free drain were demonstrable. Firm organized adhesions persisted in the tract drained where there had been fixation. The surfaces that had been merely fixed in apposition were now adherent.

Experiment 31. Similarly done. Gauze was used in place of protective. The drains were

removed at the end of 4 days, but with difficulty, and considerable bleeding followed. The dog was killed 10 days later. There had occurred a marked diminution in the size and firmness of the adhesions about the free drain, as compared to those then present where there had been intestinal fixation. Organized adhesions united the surfaces which had been merely approximated.

In even this limited number of experiments the constancy of certain phenomena demonstrates the main factors in the disappearance of adhesions, as already assumed from clinical observations; viz., the primary extent and density of the adhesions and the subsequent visceral movements.

V. DEDUCTIONS

Not only is drainage of the general peritoneal cavity impossible, but, if attempted, there results, on the contrary, a flow from the potential into the general cavity, no matter what form of drainage is used.

The discharge from the drain and the excess intraperitoneal fluid is a serous exudate, the result of mechanical irritation of the peritoneum contiguous to the drain, and, to an insignificant extent, of the general peritoneum, from the manipulation attending its insertion.

This serous exudate begins immediately and continues till about the time the fibrinous exudate accomplishes complete encapsulation of the drain by the adhesions of the surfaces whence the serum originated.

The firmness, extent, and rapidity of this encapsulation depend upon the irritation, the nature, reactivity, and quiescence of the affected surfaces (occurring in less than 6 hours in dogs).

The least disadvantageous condition is obtained when the encapsulation is effected by the omentum and parietal peritoneum.

A pre-existing, concomitant, or subsequent peritoneal infection, when not overwhelmingly severe, possibly accelerates the formation of these adhesions.

The presence of a sterile (non-nutrient) foreign body, whether or not encapsulated, is but slightly detrimental to peritoneal resistance.

The less irritating and protracted the drainage, the less extensive the resulting adhesions, which are therefore less liable to be persistent.

The greater the movement of the affected surfaces in constancy, force, and amplitude, the more certainly and rapidly adhesions disappear; but, the greater the intrinsic motility of a surface, the greater the possible functional disturbance from the adhesions affecting it.

Drains with smooth surfaces become as effectively and rapidly encapsulated as those with rough, and being less irritating, the resulting reaction is less severe and the discomfort much reduced.

Drainage from the potential and actual (peridrain) cavities is better in the presence of smooth drains, and their early withdrawal is easy, painless, and without danger of opening the general peritoneal cavity.

The dangers of displacement of a smooth drain can be overcome by inclosing a firm tube, or by disclosing contained gauze for proper fixation to the affected area.

As localized intraperitoneal drainage is alone possible, and is almost invariably associated with early complete encapsulation, it should be purposely inserted to

"extraperitonealize" the affected serosa, with the least damage to the rest of the peritoneum and functional detriment to the viscera.

VI. CLINICAL SIGNIFICANCE

There is so little comparison between the peritoneum of a healthy dog and that of a sick man, particularly when the affection is intra-abdominal, that the clinical application of principles thus established must be tempered with conservatism. There is, however, such a well-substantiated and definite relationship between these clinical and experimental observations as to indicate a sufficient physiological resemblance to justify the adoption of such possibly valuable points as are certainly harmless.

The futility of attempting drainage of the general peritoneal cavity, as well as its possible deleterious effect upon peritoneal resistance, together with the certainty of causing immediate and remote complications, however rarely, can have but one interpretation, and this consideration may be limited at once to localized drainage, which, in effect, includes hemostatic tamponade.

We have, then, but to consider how areas already "dangerous," and those that may become so, may be best rendered extraperitoneal until all danger be eliminated. To accomplish this, the isolation must be rapid, complete, and certain, with the least injury to the peritoneum, the least restriction of the normal functions of the viscera, with the earliest and most complete restitutio ad integrum of the abdomen as a whole, and, withal, the minimum of discomfort to the individual.

Any drainage material that can be approximated to the area to be excluded, and so cover it that no abnormal surface but the foreign body appears in the general peritoneal cavity, will accomplish the first purpose. It must extend to the parietes and out through an opening, either the operative incision or one secondarily made for this purpose. In so doing it should come in contact with the least possible number and extent of serous surfaces, and with those least likely to be functionally affected, and therefore between the omentum and parietes, whenever practicable. Everything should be done to promote subsequent intra-abdominal quiet for at least 12 hours, when adhesions will probably be practically encapsulated.

At the end of 24 hours the sheath of adhesions is strong enough to warrant the withdrawal of the core of the drain (which should be constructed on the principle of Mikulicz's tampon) to begin the collapse of the drain tract by the action of the intra-abdominal pressure. Thereafter, as rapidly as conditions will permit, the drain should be reduced until only the sheath remains, and then this gradually removed to insure perfect healing from the bottom.

With the drain removed and the wound healed, measures destined to cause the disappearance of the persisting adhesions should be adopted to stimulate intra-abdominal movements; e.g., purges, general and abdominal exercise, and massage.

Aside from these general principles, there is one detail that adds materially to the patient's comfort—possibly leads to better results, and is harmless. By enveloping a gauze drain, *after it is inserted*, as completely as practicable with the

thinnest gutta-percha tissue, which should entirely surround the whole distal portion and project beyond the skin, those very sensitive cutaneous adhesions are entirely avoided, the intraperitoneal reaction is less severe, and the removal of the drain is comparatively painless, besides being devoid of the same danger of tearing into the general peritoneal cavity. If the protective is not properly inserted, there is danger that it may become displaced, or the whole drain pull out with the first traction.

VII. CONCLUSIONS

Drainage of the general peritoneal cavity is physically and physiologically impossible.

The relative encapsulation of the drain is immediate.

The absolute encapsulation occurs early (less than 6 hours in dogs), and can be retarded, but not prevented.

The serous external discharge is an exudate due to the irritation of contiguous peritoneum by the drain.

There is a similar inward current from the potential into the general cavity.

This external exudate diminished remarkably with the formation of encapsulating adhesions.

These adhesions, under approximately normal conditions, form about any foreign body.

Their extent and density depend on the degree and the duration of the irritation of this body.

Primarily fibrinous, these adhesions become organized in a few days (three days in dogs).

If the irritation persists, they become progressively more mature fibrinous tissue.

After irritation ceases, their disappearance depends principally upon a mechanical factor—the ability of the involved surfaces to pull themselves or to be pulled loose.

Drains should be the least irritating, and should be gradually and finally removed as soon as possible.

Irrigation through drains is futile to prevent adhesions, and dangerous.

After a drain is inserted, all intra-abdominal movements should be reduced to a minimum.

As soon as the drain is removed, intra-abdominal activity should be stimulated, to aid in the disappearance of the remaining adhesions.

Peritonitis, if not too severe, possibly aids in the rapidity of the encapsulation of the drain.

A drain in the presence of infection is deleterious to peritoneal resistance, and should only be introduced to exclude more malign influences.

Postural methods, unless destined to facilitate encapsulation, are both futile and harmful, as far as drainage is concerned.

Peritoneal drainage must be local, and unless there is something to be gained by rendering an area extraperitoneal, or by making from such an area a safe path

of least resistance leading outside the body, there is, aside from hemostasis, no justification for its use.

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BOOK REVIEWS

The editors of THE AMERICAN SURGEON *will at all times welcome new books in the field of surgery and will acknowledge their receipt in these pages. The Editors do not, however, agree to review all books that have been submitted without solicitation.*

Intestinal Obstructions: Physiological, Pathological and Clinical Considerations with Emphasis on Therapy, Including Description of Operative Procedures. Third Edition. By OWEN H. WANGENSTEEN, B.A., M.D., Ph.D., Professor of Surgery, University of Minnesota, Minneapolis, Minnesota. Springfield, Illinois, Charles C Thomas. Price $15.50.

It seems incredible that the first manuscript of this monograph was rejected by three publishers as the author states in his preface. It shows how shortsighted a publisher occasionally may be. The thrice rejected manuscript was destined to become a monographic classic.

Here is a book of 800 pages which contains the collected knowledge of one of the most important subjects in surgery. It is divided into four parts, as follows: Part I. Physiological, Pathological and Clinical Considerations with Emphasis on Therapy, Including Description of Operative Procedures. Part II. General Diagnostic Considerations in the Recognition of Bowel Obstruction. Part III. General Therapeutic Considerations in the Management of Bowel Obstructions. Part IV. The Special Obstructions.

There are 200 figures composed of charts, drawings and roentgenograms which serve to clarify the text. At the end of each chapter there is a long list of references which indicate the thoroughness of the author's study.

Here is the story of intestinal obstruction brought up to date. It is a reference book of the first quality. It deserves the highest praise.

THOMAS G. ORR, M.D.

BOOKS RECEIVED

Books received are acknowledged in this section, and such acknowledgement must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

Collected Papers of the Mayo Clinic and the Mayo Foundation. Edited by RICHARD M. HEWITT, B.A., M.A., M.D.; A. B. NEVLING, M.D.; JOHN R. MINER, B.A., Sc.D.; JAMES R. ECKMAN, A.B., M.A., Ph.D.; M. KATHERINE SMITH, B.A.; CARL M. GAMBILL, A.B., M.D., P.P.H.; FLORENCE SCHMIDT, B.S.E.; and GEORGE G. STILWELL, A.B., M.D. Volume XLVI, 1954. Published June, 1955., Philadelphia and London, W. B. Saunders Company.

A Textbook of Medicine. Edited by RUSSELL L. CECIL, M.D., Sc.D., Professor of Clinical Medicine Emeritus, Cornell University, New York and ROBERT F. LOEB, M.D., Sc.D., D.Hon.Causa., LL.D., Bard Professor of Medicine, Columbia University, New York. Associated Editors: Alexander B. Gutman, M.D., Ph.D., Professor of Medicine, Columbia University, New York; Walsh McDermott, M.D., Livingston Farrand Professor of Public Health and Preventive Medicine, Cornell University, New York; Harold G. Wolff, M.D., Professor of Medicine (Neurology), Cornell University, New York. Ninth Edition, illustrated. Philadelphia & London, W. B. Saunders Company, 1955. Price $15.00.

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